Deploying Quality of Service (QoS)

Tighten your Seat Belts…

MSTP

Different Requirements

MSTP

Data	Voice
Bursty	Smooth
Greedy	Benign
Loss Sensitive	Loss Insensitive
Delay Insensitive	Delay Sensitive
TCP Retransmits	UDP Best Effort

QoS – Terminology

QoS: A working definition

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QoS ingredients:

- Delivery of controlled delay, jitter, or loss to certain classes of traffic
- Differentiation of the service delivered to different classes
  - –e.g. a lightly loaded best-effort network delivers good service to all traffic, but isn't displaying QoS
  - –Differentiation invariably implies mechanisms to classify & queue (schedule) traffic

Cisco QoS Toolkit

MSTP

Classification

- CoS
- ToS
- IPP
- DIFFSERV
- Policy Maps
- Class Maps
- PBR
- CB Packet Marking
- NBAR
- ATM CLP
- FR DE
- Marking
- MPLS EXP Bits

Congestion MGMT

- FIFO
- PQ
- CQ
- WFQ
- CBWFQ
- LLQ and dLLQ
- FR LLQ
- RTP Reserve
- IP RTP Priority
- FR IP RTP Priority
- FR PVC Interface PQ
- FR BECN

Congestion Avoidance

- WRED
- dWRED
- Flow based WRED
- DIFFSERV WRED

Policing & Shaping

- CAR
- Policing
- Traffic Shaping
- Generic Traffic Shaping
- FR Traffic Shaping
- Class based Shaping
- Distributed Traffic Shaping

Switch QoS

- CoS
- ToS
- IPP
- DSCP
- Trusted Boundary
- Extended Trust
- Aggregate Policing
- Microflow Policing
- Traffic Shaping
- Bandwidth Suppression
- IPP <> CoS Mapping
- DSCP <>CoS Mapping
- CoS <>DSCP Mapping
- Tx Queue Ratios
- WRR Weight
- Strict priority
- Deficit WRR
- DSCP Mutation Map
- CoS <>Queue Map
- WRED
- Bandwidth Allocation
- Queue Threshold MGMT

Link Efficiency

- PPP Fragmentation
- FRF12
- cRTP

Signalling

- RSVP
- RSVP w/LLQ
- RSVP w/FR
- RSVP over ATM
- COPS for RSVP
- SBM

Why QoS? And when do we need it?

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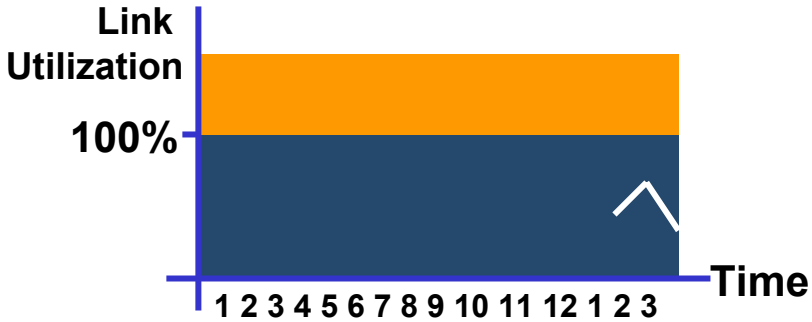
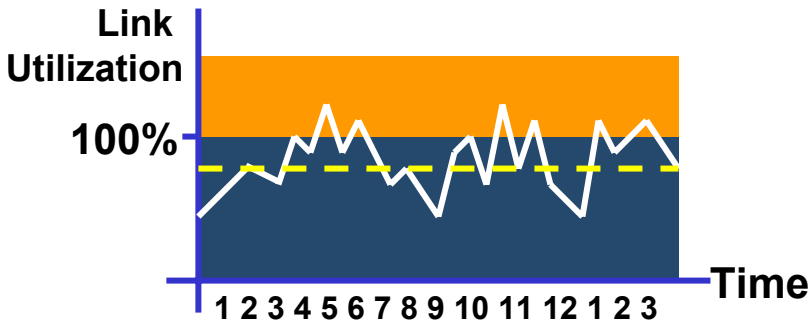
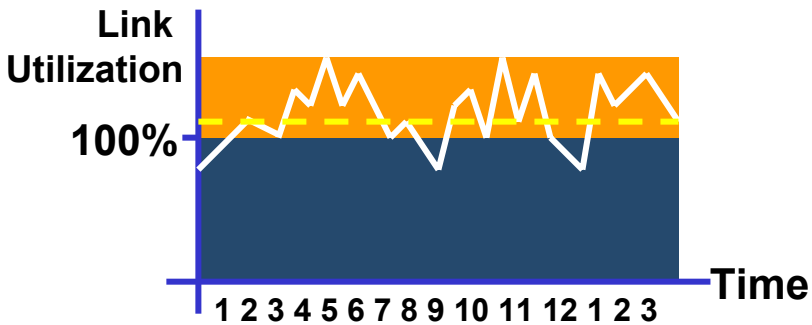


- Link over-provisioned
- May not be cost effective
- No QoS required but a safety net



- **Transient congestion**
- **QoS most useful**



- **Link highly over-subscribed**
- **QoS somewhat useful but more bandwidth required**

Assigning Priority

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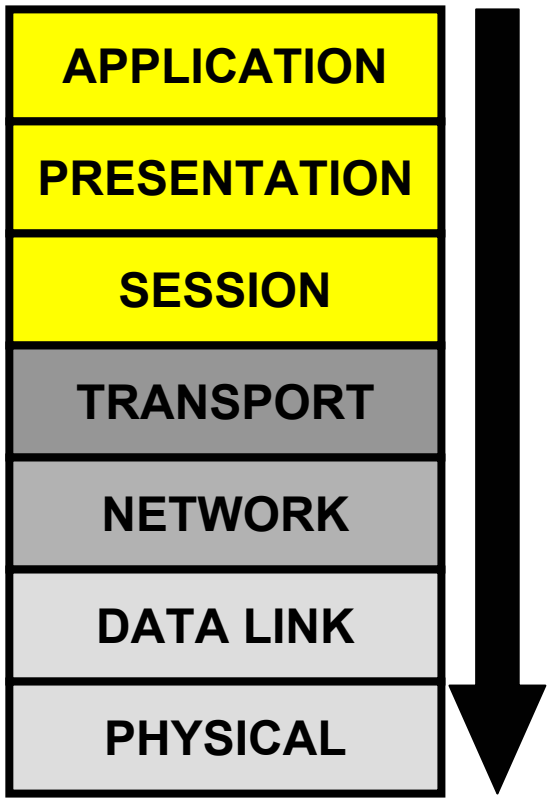
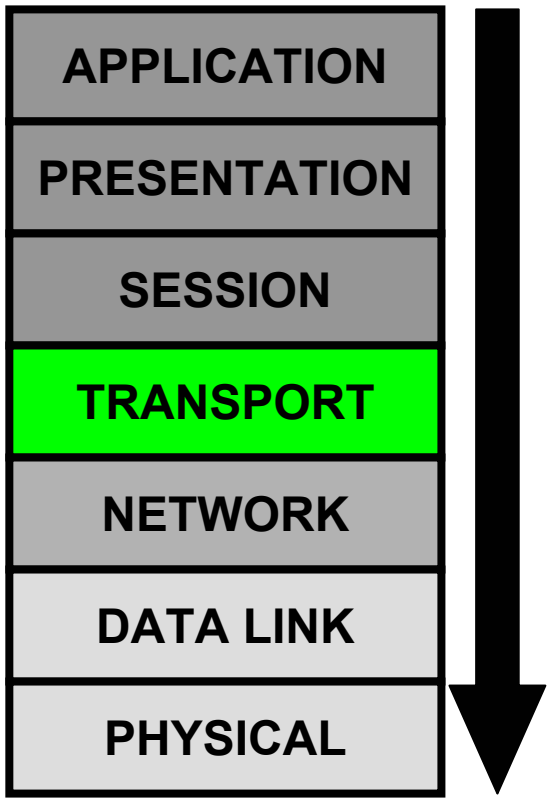


DATA

Application Layers create the data ready for transport

Assigning Priority

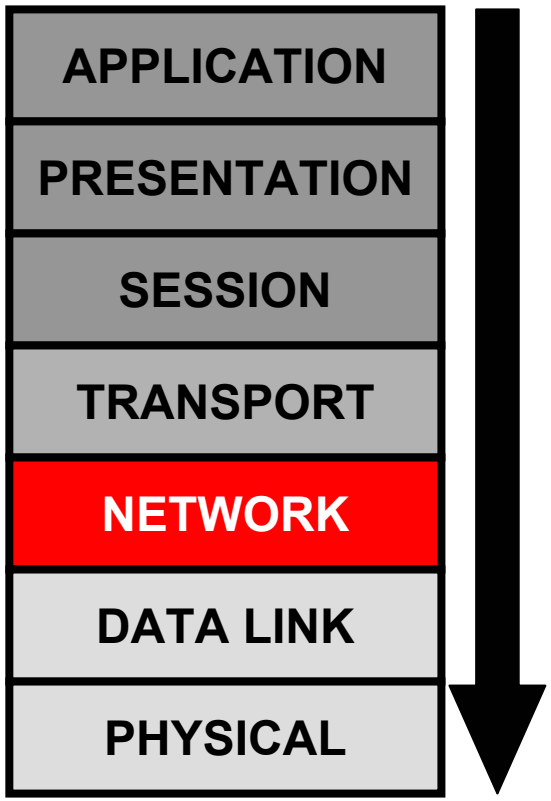
MSTP

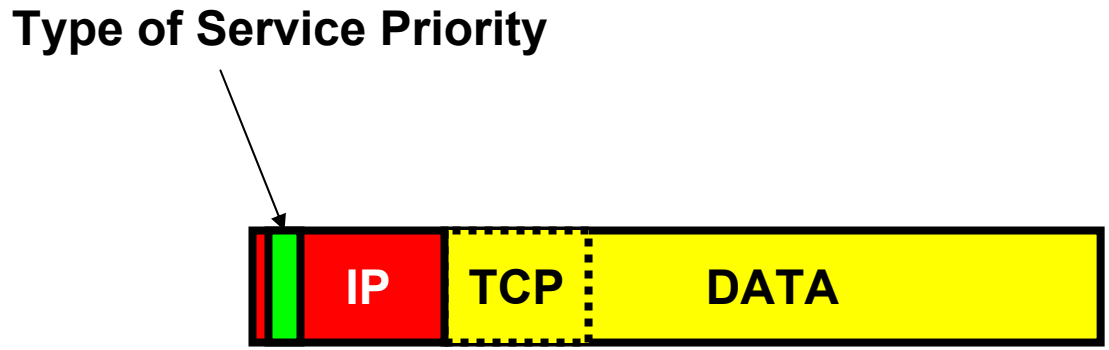


Transport Layer assigns port number and manages connection

Assigning Priority

MSTP

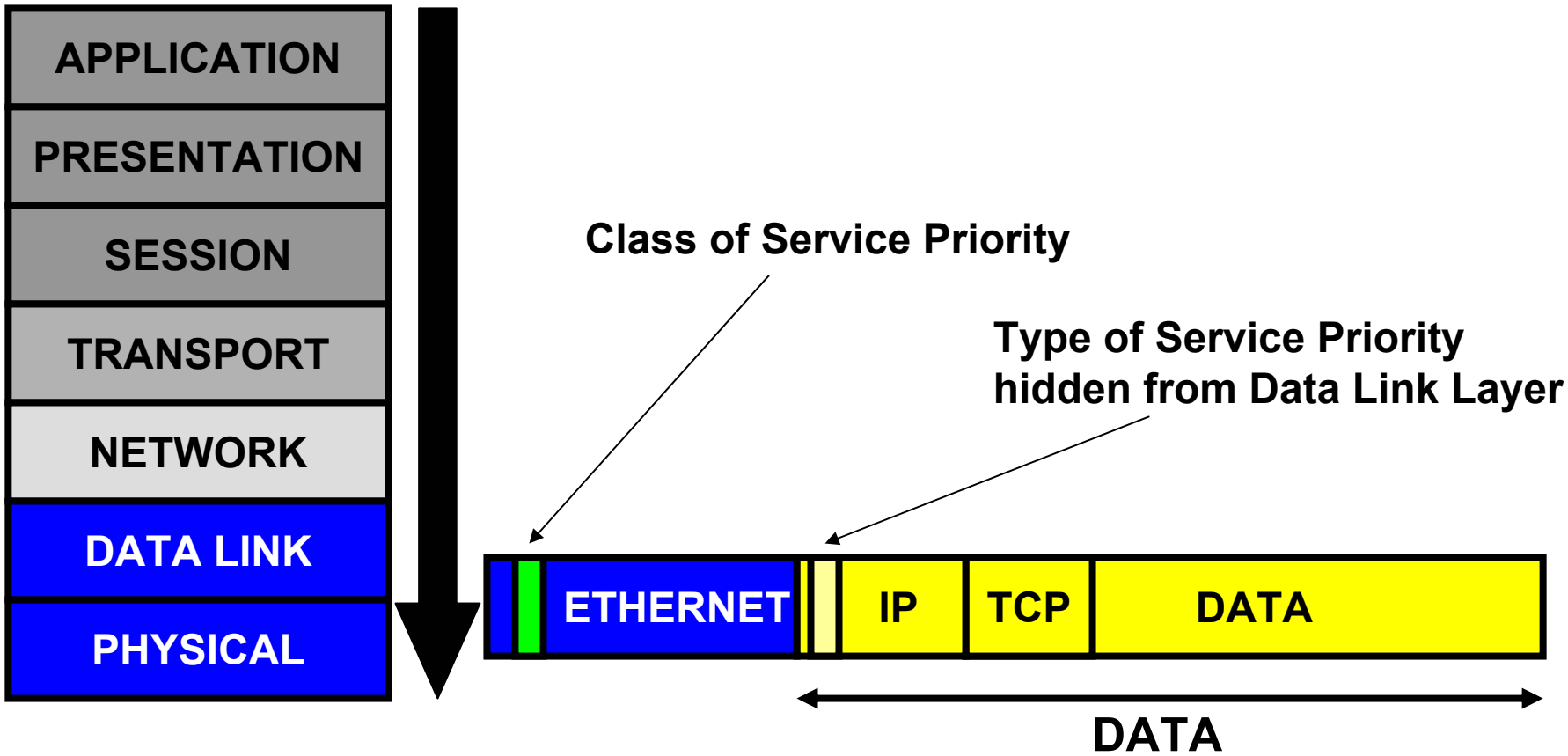




Network Layer tags packet with priority and addressing information

Assigning Priority

MSTP



Data Link Layer tags packet with priority and addressing information

Priority Assignment – CoS and ToS

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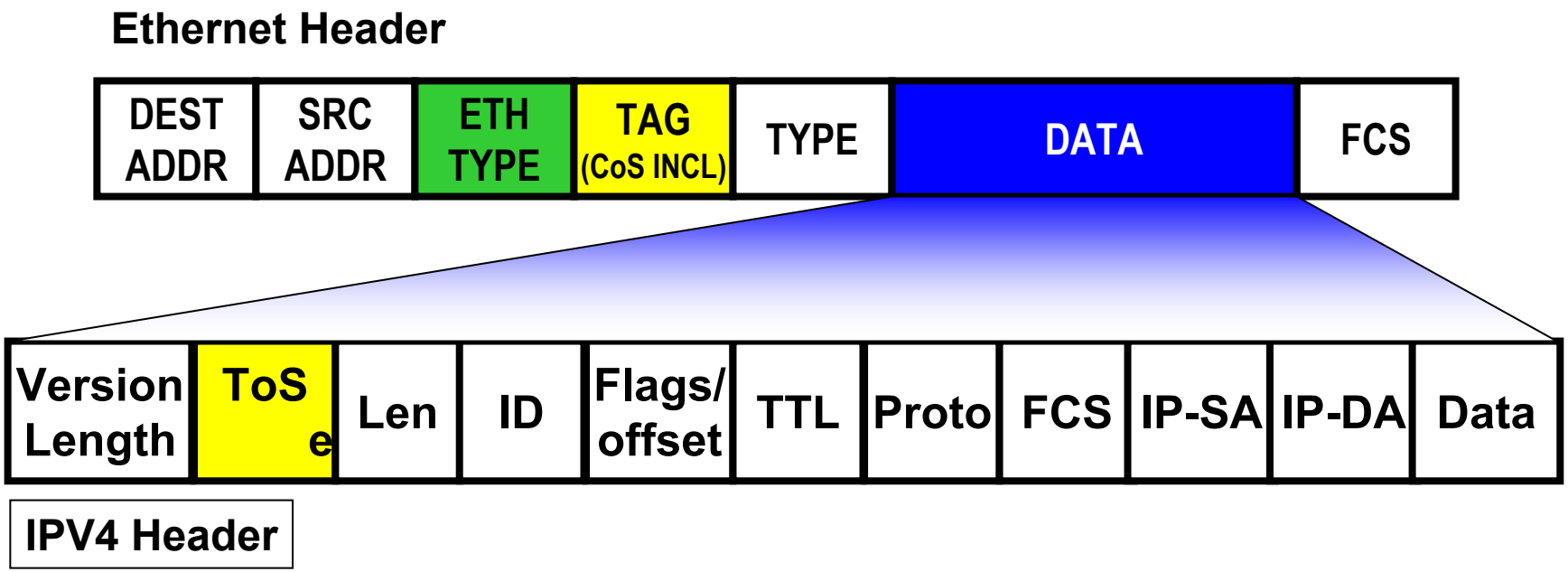
Class of Service assigns a 3 bit priority yielding 8 priority levels
CoS used by switches to determine the assigned level of service

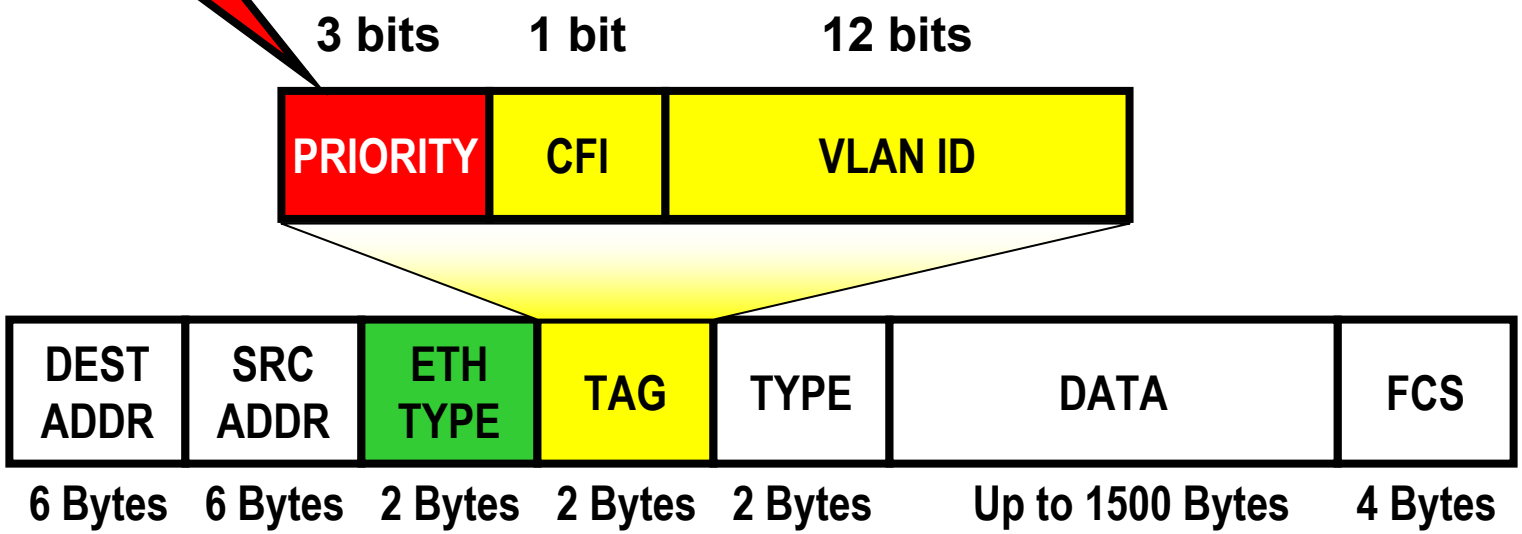


Type of Service assigns a 3 or 6 bit priority yielding 8 or 64 priority levels
ToS is also used by switches to determine the assigned level of service

CoS in 802.1Q (802.1p)

000 – 0
001 – 1
010 – 2
011 – 3
100 – 4
101 – 5
110 – 6
111 – 7

Part of IEEE 802.1Q specification
2 byte Tag field contains 3 bit priority field
Tag referred to as 802.1p priority
802.1Q tagging extends 1518 byte ethernet frame to 1522 bytes



CoS in Inter Switch Link (ISL)

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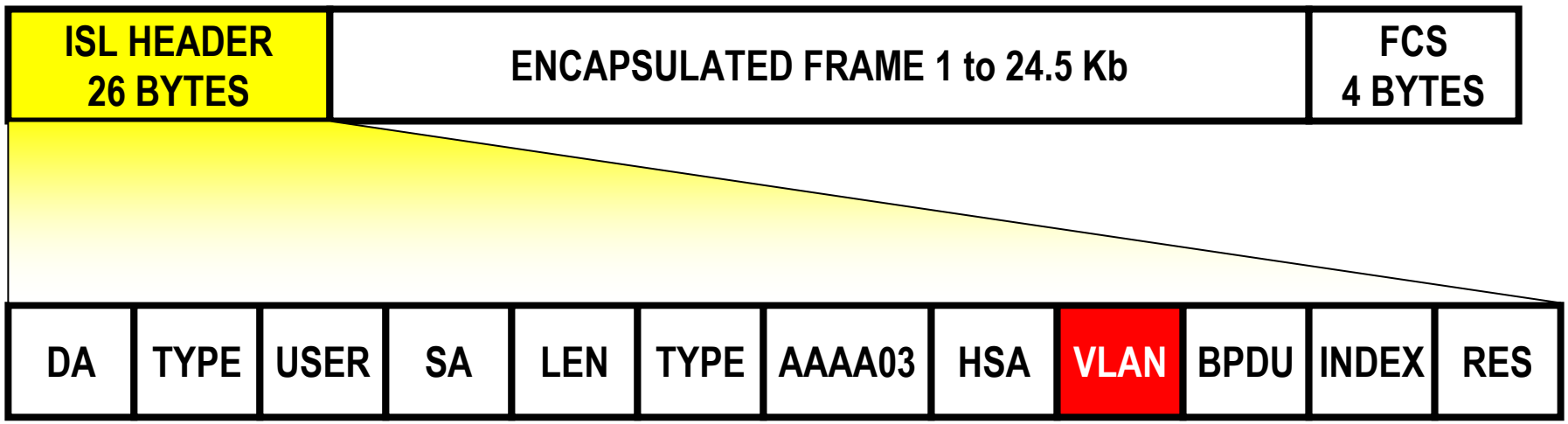
ISL is a Cisco proprietary VLAN tagging mechanism that incorporates a priority to assign up to 8 priority levels to an Ethernet frame…..



VLAN Field contains 10 bit VLAN tag (identifier) yielding 1024 VLAN's and 3 bit priority field for assigning priority to frame

Type of Service – ToS (Layer 3)

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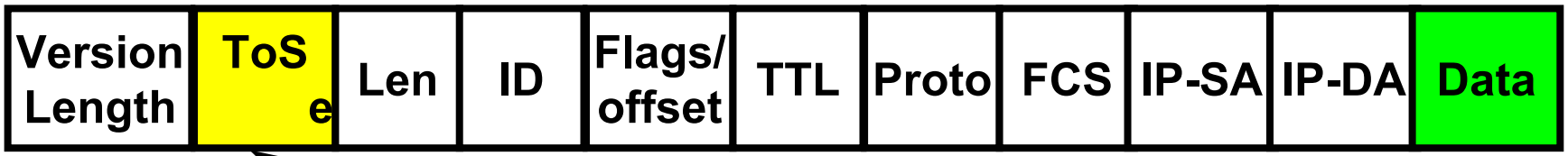
IP Version 4 Header



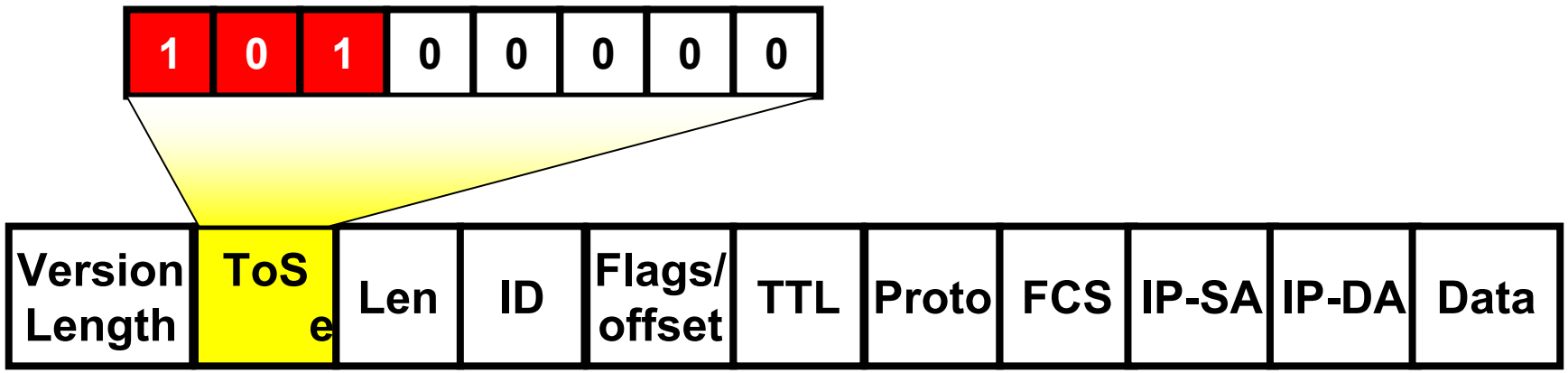
Priority is assigned to an IP Packet using bits in the the ToS Field

Two Mechanisms for reading the Priority bits

IP Precedence
Differentiated Services Code Point (DSCP)

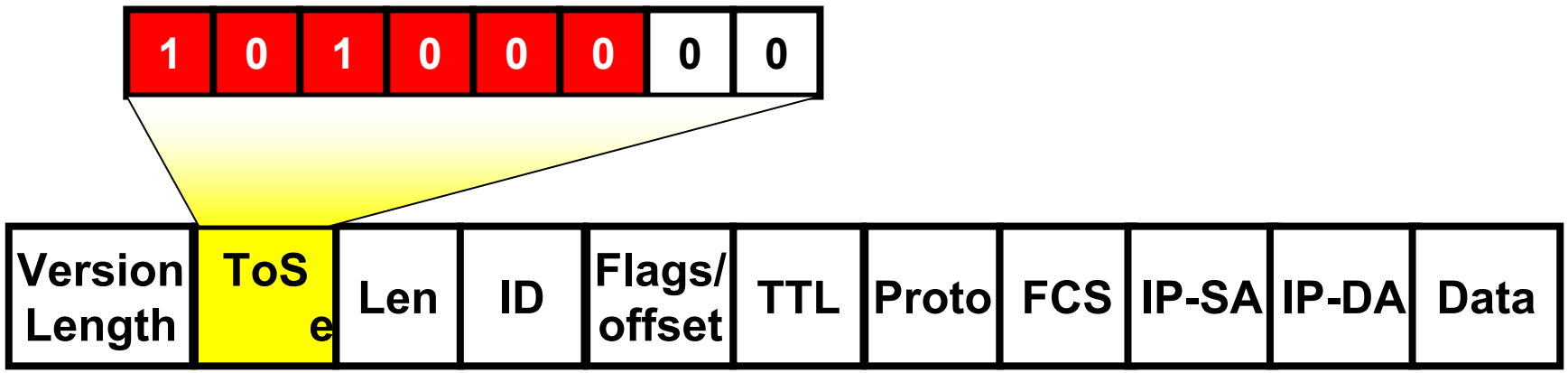
IP Precedence

IP Precedence has been in use for many years
Uses first 3 most significant bits of ToS field
2^^3 (2 to the power of 3) yields 8 different priorities
0 is lowest priority
7 is highest priority



Differentiated Services Code Point - DSCP

DSCP is a more recent innovation
Uses first 6 most significant bits of ToS field
2^^6 (2 to the power of 6) yields 64 different priorities
0 is lowest priority
63 is highest priority



Assigning Trust

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..Trust is a port assignment instructing the port whether to trust (leave) existing priorities set on incoming frames or to rewrite the Priority back to zero…

Policing (Rate Limiting)

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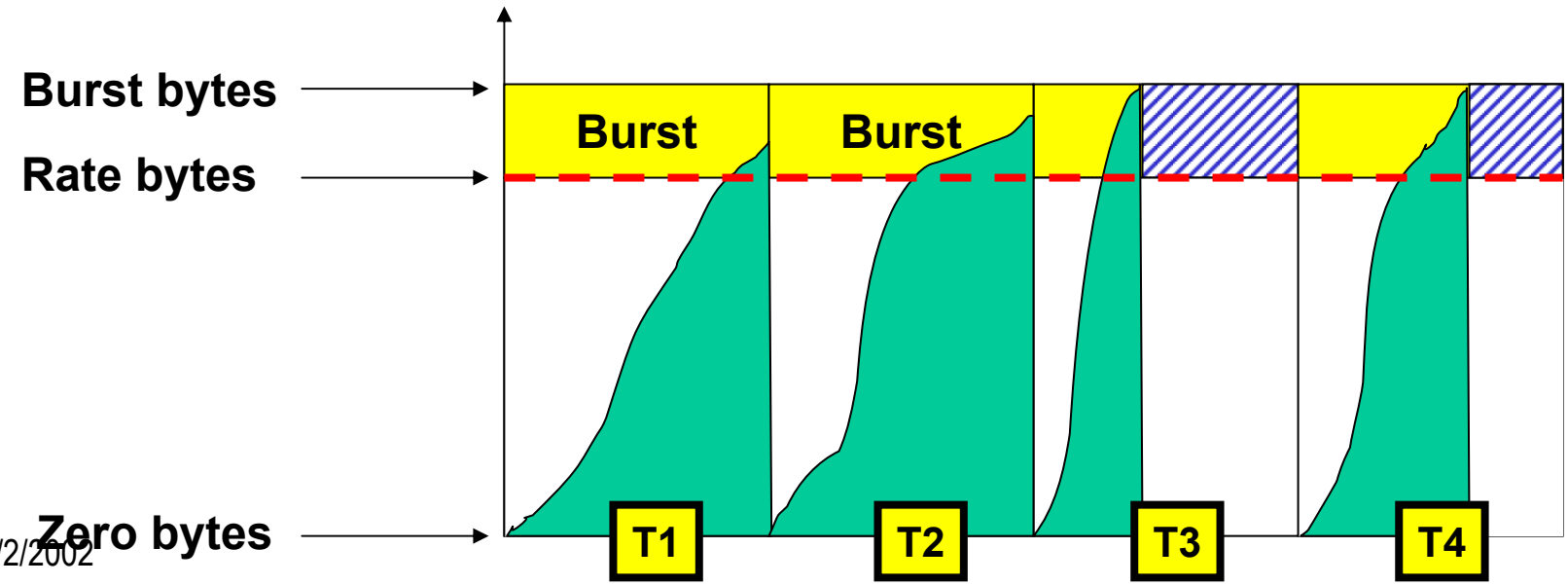
The process of defining a policy to limit the amount of traffic sent

Allows you to define an incoming rate of traffic per interval (known as burst). The excess is dropped or marked down

Then define the rate at which the data can be sent per interval and the replenishment rate for tokens



Policing – Aggregates and Microflows

MSTP

Process of policing is to rate limit a flow down to a prescribed rate

Can apply microflow and/or aggregate policing to PORT and/or VLAN

Data IN

Data OUT

40Mb

30 Mb

Aggregate (Limit total traffic count)

25Mb Total

40 Mb

30 Mb

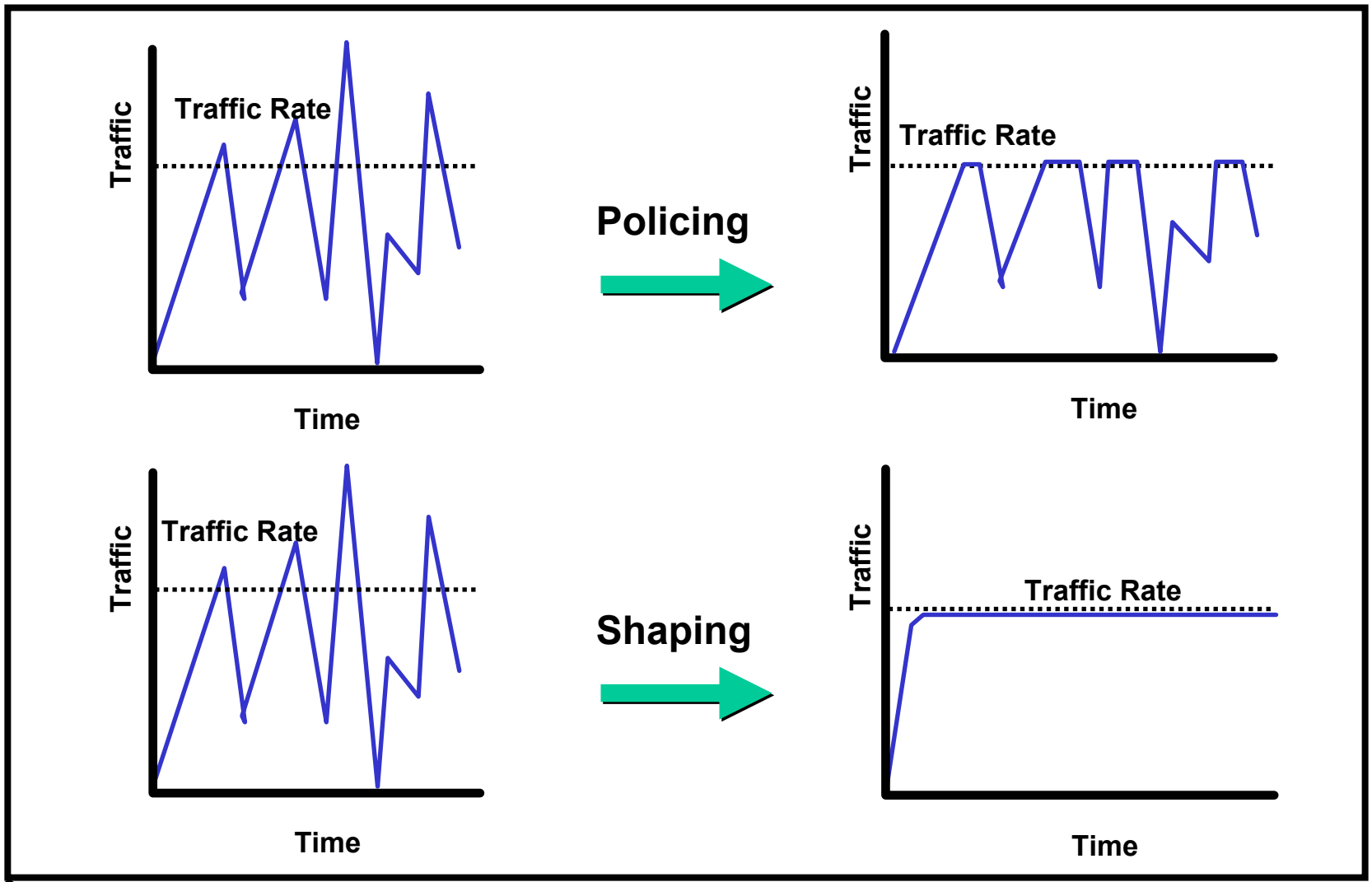
Microflow (Limit flow traffic count)

8Mb

30 Mb

Policing vs. Shaping

MSTP

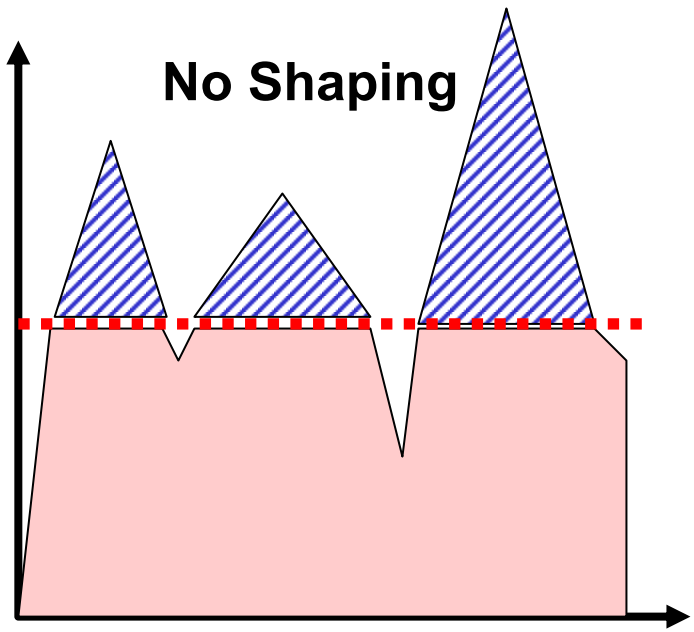


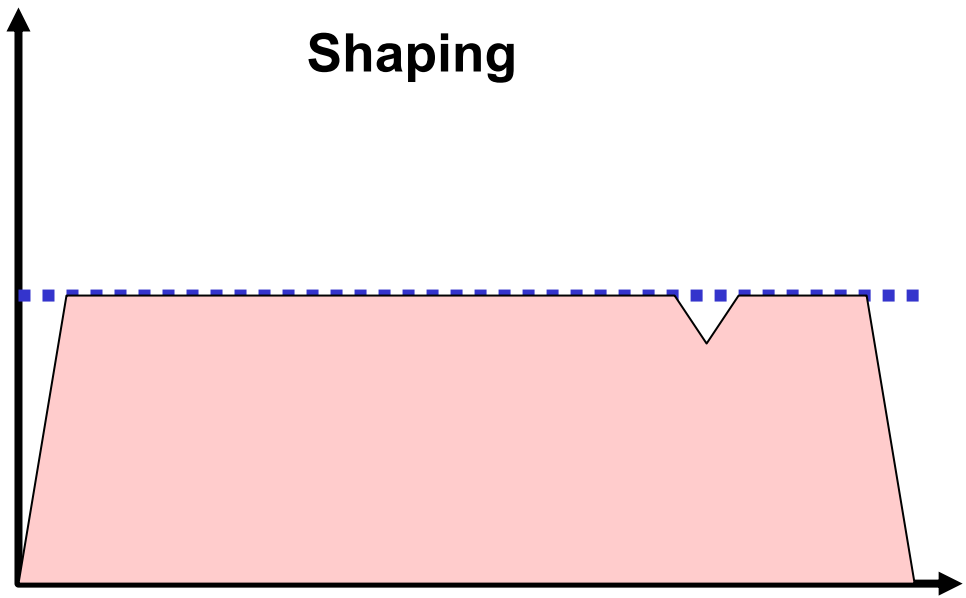
Traffic Shaping

MSTP

..Traffic Shaping allows the switch to smooth the flow of data being sent..

..Excess data is typically buffered as opposed to being dropped (as with Policing)…





Policy Maps and Class Maps

POLICY MAP

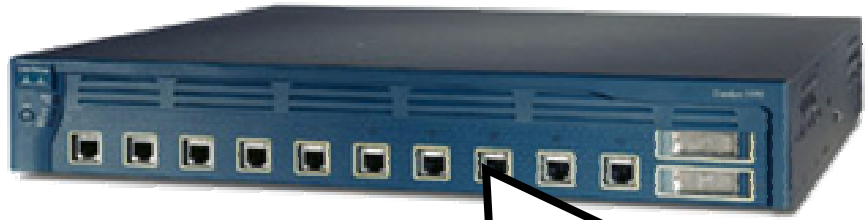
One Policy Map per interface

Up to 255 Class Maps within a Policy Map

CLASS MAP

Uses an ACL to identify traffic that this class map will be used to perform a set of actions on

Defines a set of characteristics to be performed on matched traffic

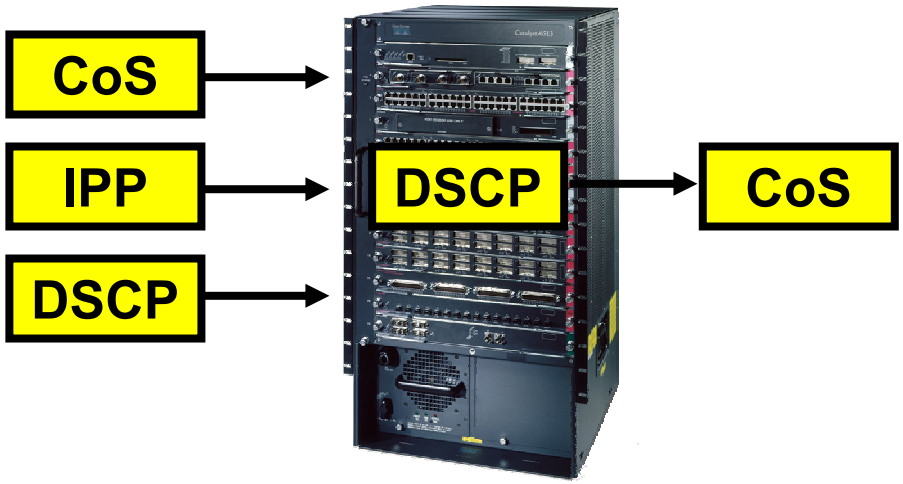


```
[snip]
access-list 101 permit 10.1.1.0 any
access-list 102 permit 192.168.1.0 any

policy-map FRED
  class-map policer1 access-group 101
    trust cos
    police 1000000 100000 exceed-action drop
  class-map policer1 access-group 102
    police 2000000 200000 exceed-action drop

Interface Gigabitethernet 0/1
  Service policy input FRED
[snip]
```

Maps

MSTP

Ingress maps are used to take an existing priority and map it to an internal DSCP value used by the switch to assign service levels to the frame as it is in transit



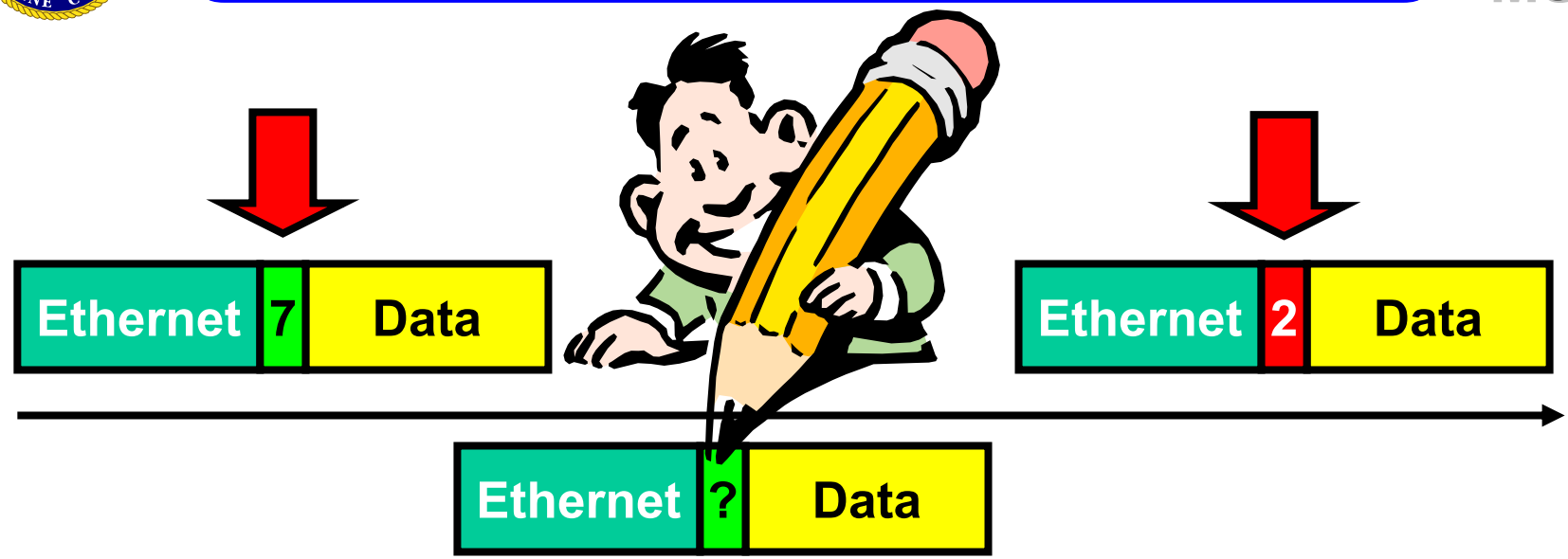
DSCP Value	CoS Value
0	0
8	1
10	1
16	2
18	2
24	3
26	3
32	4
34	4
40	5
46	5
48	6
56	7

MAP Example

Egress maps are used to rewrite CoS for applicable frames from the internal DSCP on egress from the switch

Marking

MSTP



..The process of the switch modifying the priority of an incoming Frame…

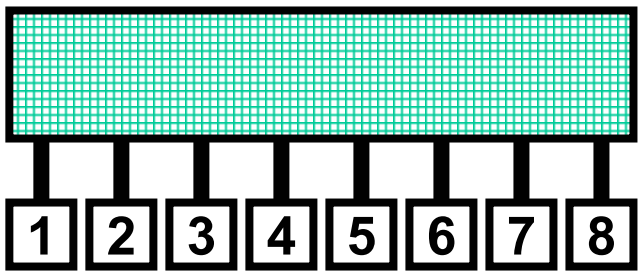
..The modified priority can be either the CoS priority or the ToS priority or both..

Buffering

MSTP

..Across the Catalyst Switch Family, buffering is implemented in either a shared fashion (across all ports) or on a per port basis..

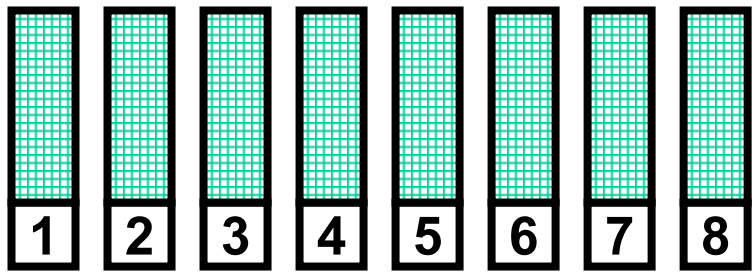
Shared Memory



Switch Ports

Catalyst 2950
Catalyst 3550
Catalyst 4000

Per Port Buffers



Switch Ports

Catalyst 6500

Congestion Avoidance

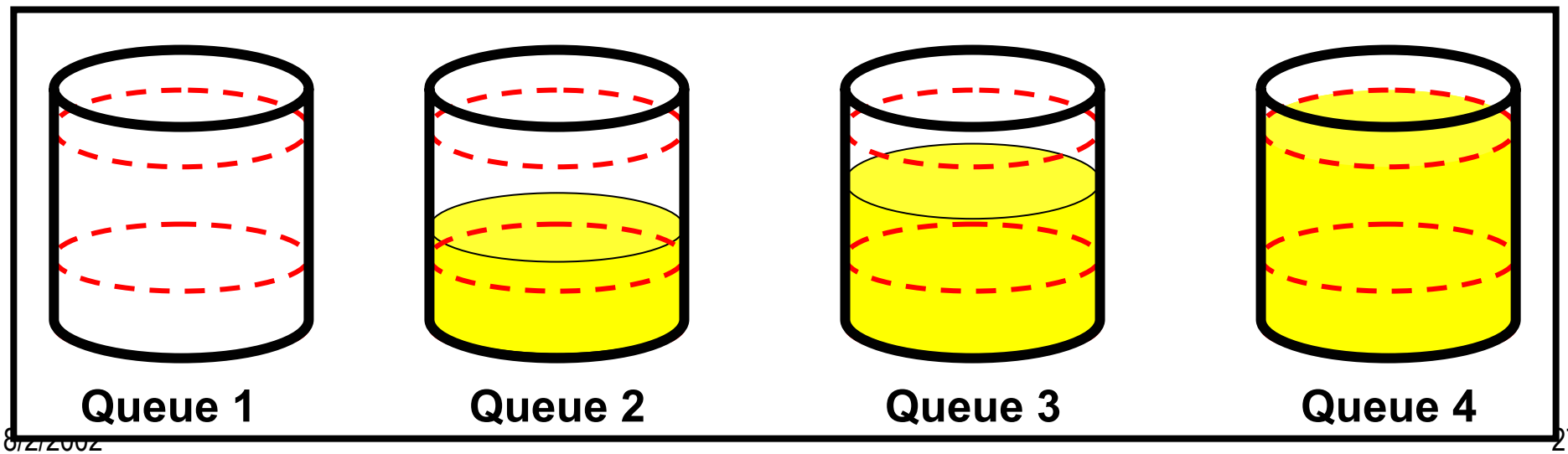
MSTP

..The process of managing the queues to avoid them overflowing..

Two mechanisms,..
Tail Drop and Weighted Random Early Discard (WRED)

Tail Drop simply drops last in frames when queues are full

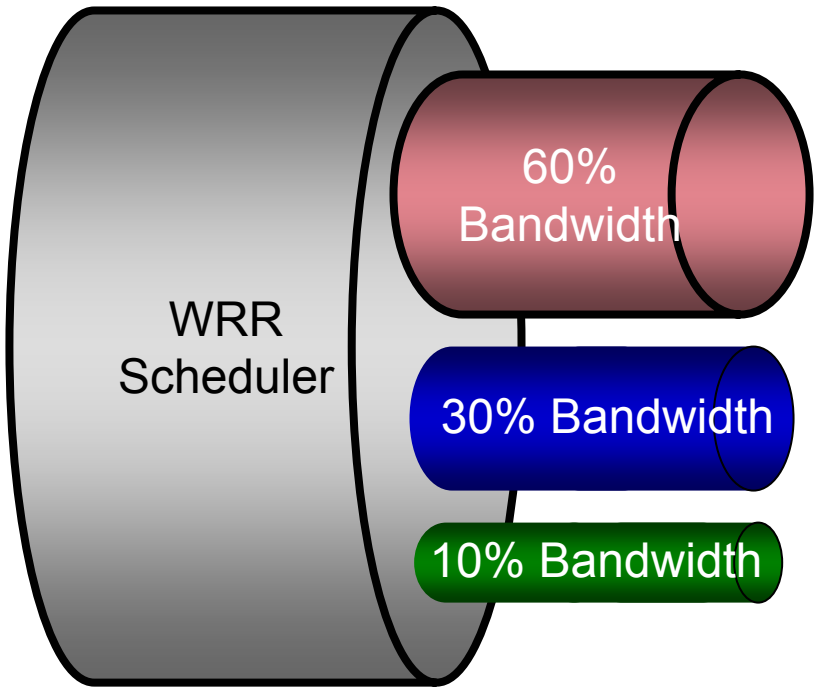
WRED manages queues using thresholds to identify which frames can be dropped when a threshold is exceeded



Scheduling – Weighted Round Robin

MSTP

..Weighted Round Robin algorithm empties a queue based on a "weight" that determines how many frames will be sent from the queue. Once the queue has had its proportion of frames sent, the algorithm moves on to the next queue and continues the process..



Congestion Management

Queuing Summary (updated)

MSTP

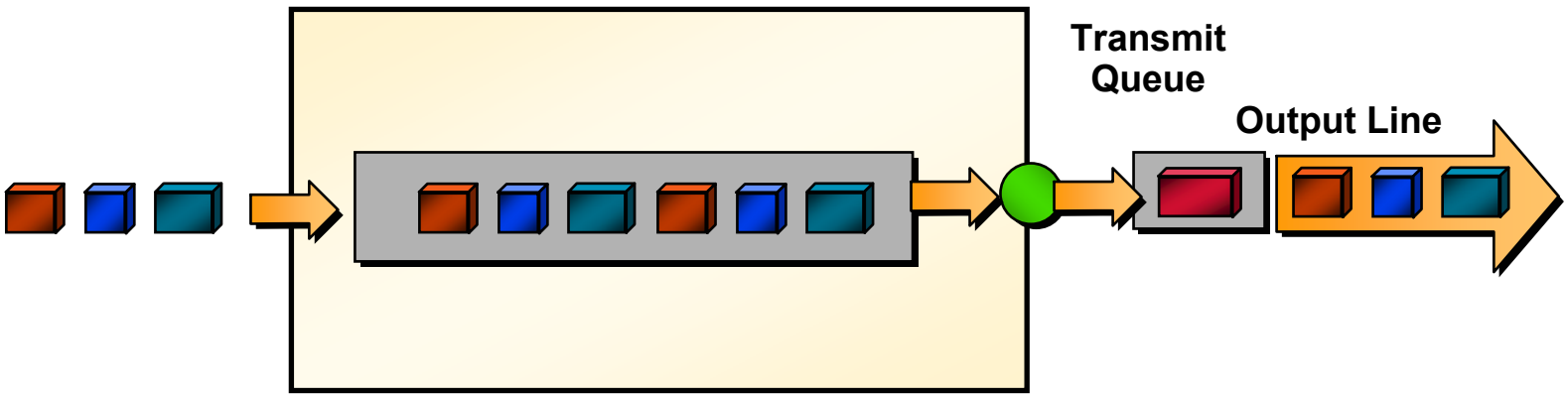
	PQ	CQ	WFQ	PQWFQ	CBWFQ	LLQ (PQ-CBWFQ)
Classification	Protocol, interface	Protocol, interface	IP Prec, RSVP, RTP Reserve, protocol, port	VoFR and IP RTP Priority	Mod CLI	VoFR and Mod CLI
# queues	4	16	Per flow	1 PQ + WFQ	64 classes	1 PQ + CBWFQ
Scheduling	Strict priority	Round-robin	Fair (weight, arrival time)	PQ: Strict WFQ: Fair	Fair: weight and BW	PQ: Strict CBWFQ: Fair/BW
Delay guarantee	Yes	No	No	Yes	No	Yes
BW Guarantee	No	No	No	PQ: yes WFQ: No	Yes	Yes
Used for Voice	No	No	Last resort	Yes	No	Yes

Queuing Algorithms

MSTP

- Congestion management algorithms
  - –First In First Out
  - –Weighted Fair Queuing (WFQ)
  - –Priority Queue/Weighted Fair Queuing (PQ/WFQ).
  - –Class based WFQ (CB-WFQ) and LLQ

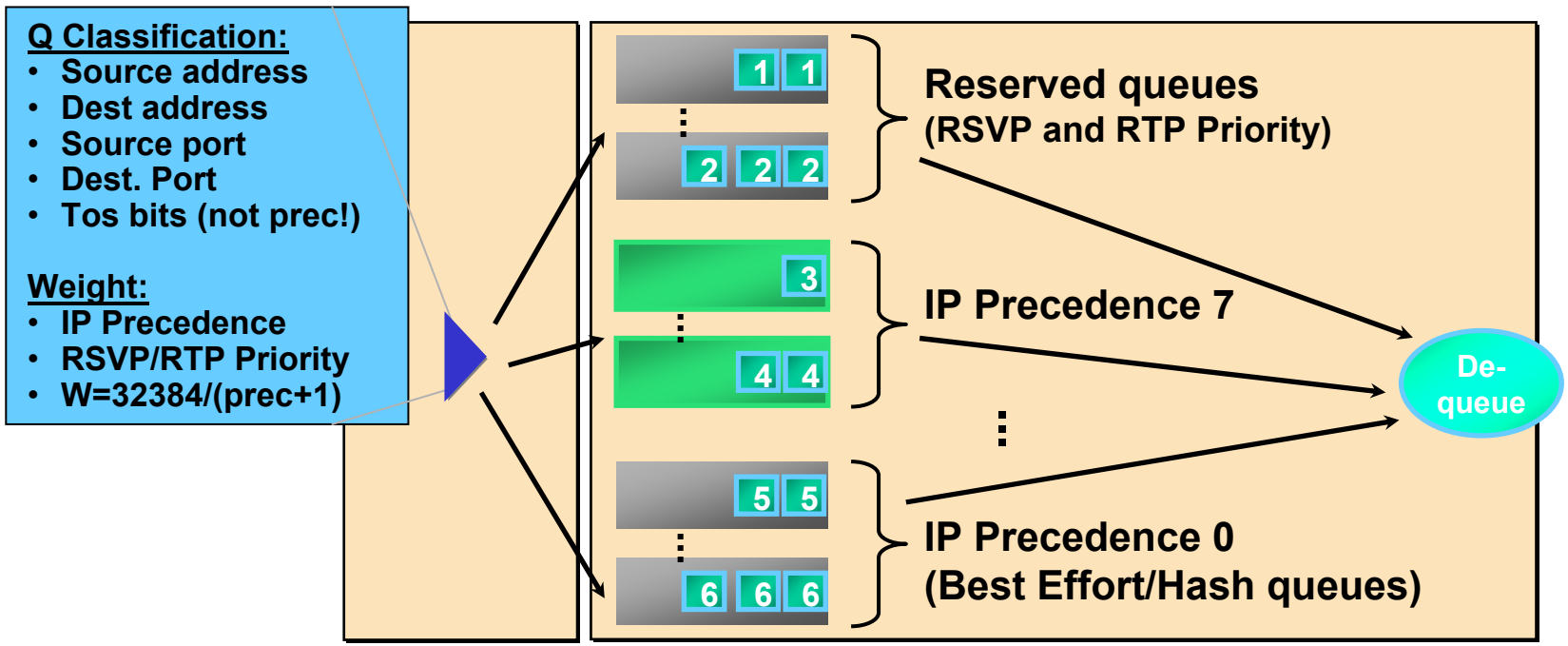
First In First Out (FIFO)



- Simplest Queuing Algorithm
- "packets leave in order of arrival"
- Fixed Queue Lengths (default 40)
  - –Result in dropping from tail of queue under load

Weighted Fair Queuing (WFQ)

MSTP



Weighted Fair Queuing

MSTP

- Provides relative bandwidth guarantees and dropping mechanism
  - Fair Queuing (FQ) allocates equal share of bandwidth to each active queue
  - Weighted Fair Queuing (WFQ) allows for unequal allocation of bandwidth
  - sub_Queue BW= BW*(TOS+1)/ Σ (TOS)

WFQ

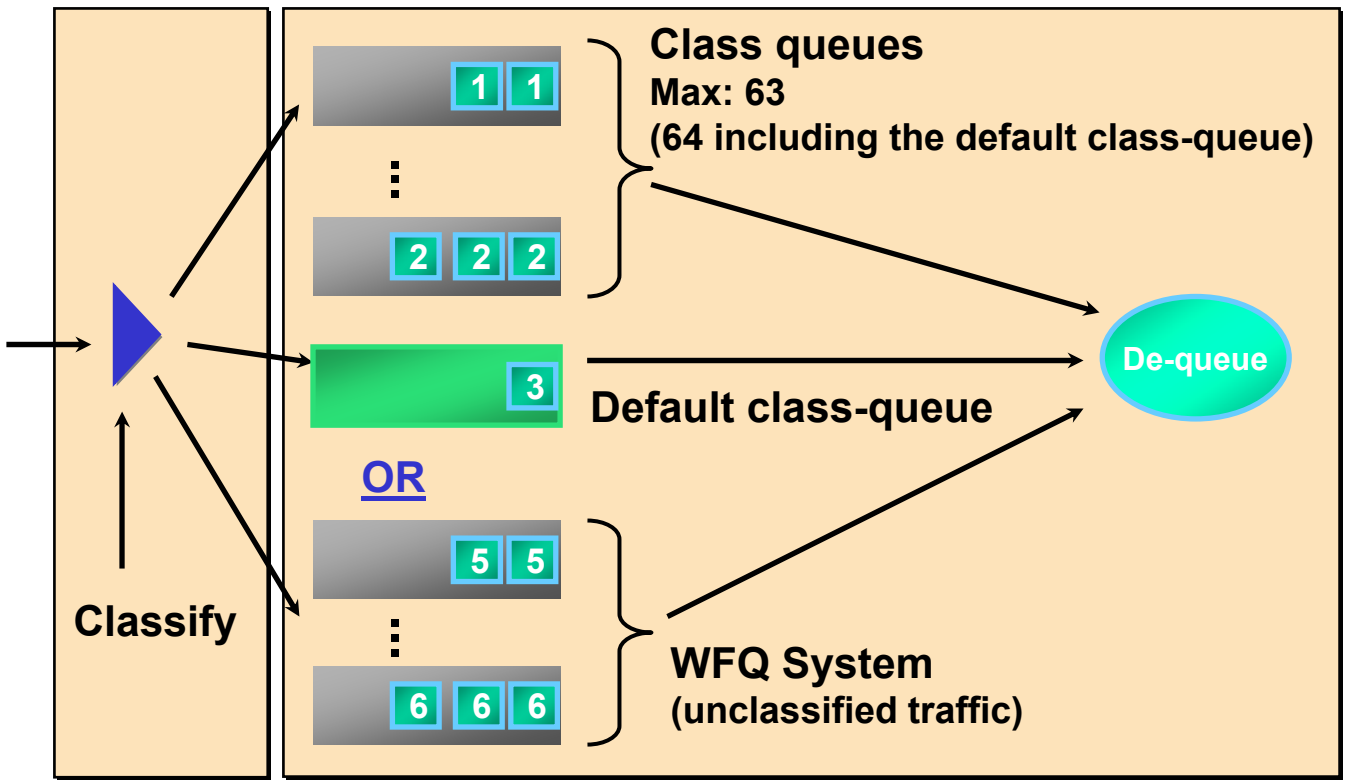
MSTP

• 1 FTP	- Tos 0	get	1/16*48K = 3 Kbps
• 1 FTP	- Tos 0		1/16*48K = 3 Kbps
• 1 Telnet	- Tos 4		5/16*48K = 15 Kbps
• 1 HTTP	- Tos 2		3/16*48K = 9 Kbps
• 1 Voice	- Tos 5		6/16*48K = 18 Kbps

Σ (Tos)= 16

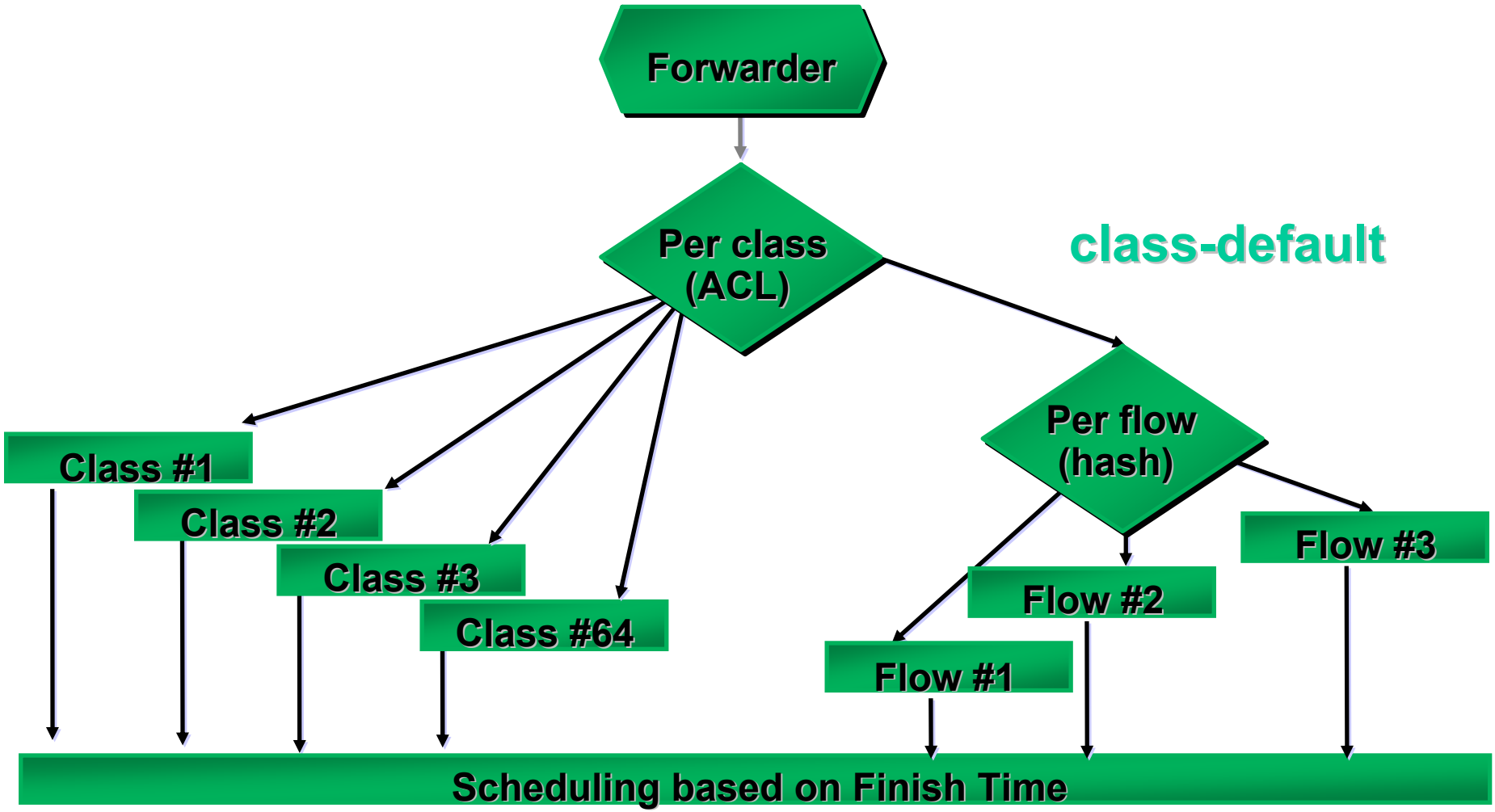
Class-Based WFQ (CBWFQ)

MSTP



CBWFQ

MSTP


Forwarder
Per class (ACL)
class-default
Per flow (hash)
Class #1
Class #2
Class #3
Class #64
Flow #1
Flow #2
Flow #3
Scheduling based on Finish Time

CBWFQ

- **64 Classes** (63 + default)
  - Bandwidth x (min guarantee)
  - wRED within classes
- **"default class" : class-default**
  - fair-queue & queue-limit
  - fair-queue & red
  - bandwidth & queue-limit
  - bandwidth & red
- By default sum of BWclasses <=75% BW

CBWFQ - Example

- 4 classes (multimedia, www, ftp, best effort)
- Congested link is 10 Mbps
- Minimum required BW:
  - Multimedia - 3 Mbps
  - www - 2.25 Mbps
  - Ftp - 1.5 Mbps
  - BE - 750 Kbps

CBWFQ - Example

Class Declaration

```
Router(config)#class-map multimedia
Router(config-cmap)#  match access-group 101
Router(config-cmap)#class-map ftp
Router(config-cmap)#  match access-group 103
Router(config-cmap)#class-map www
Router(config-cmap)#  match access-group 102
Router(config-cmap)#end
Router(config)#access-list 101 permit ip host 172.21.32.63
  host 25.1.1.5
Router(config)#access-list 102 permit tcp any eq 80 any eq
  80
Router(config)#access-list 103 permit tcp any eq 21 any eq
  21
```

CBWFQ - Example


```
Router#show class-map
 Class Map multimedia
 Match access-group  101
 Class Map class-default
 Match any
 Class Map ftp
 Match access-group  103
 Class Map www
 Match access-group  102
```

CBWFQ - Example

- Policy Declaration

```
Router(config)#policy-map mypolicy
Router(config-pmap)#  class multimedia
Router(config-pmap-c)#   bandwidth 3000
Router(config-pmap-c)#  class www
Router(config-pmap-c)#   bandwidth 2250
Router(config-pmap-c)#  class ftp
Router(config-pmap-c)#   bandwidth 1500
Router(config-pmap-c)#  class class-default
Router(config-pmap-c)#   bandwidth 750
```

CBWFQ - Example


```
Router#sh policy-map
 Policy Map mypolicy
  Weighted Fair Queueing
    Class multimedia
      Bandwidth 3000 (kbps) Max Thresh 64 (packets)
    Class www
      Bandwidth 2250 (kbps) Max Thresh 64 (packets)
    Class ftp
      Bandwidth 1500 (kbps) Max Thresh 64 (packets)
    Class class-default
      Bandwidth 750 (kbps) Max Thresh 64 (packets)
```

CBWFQ - Example

- Service Declaration

```
Router(config)#int e1/1
Router(config-if)#service-policy out mypolicy
```

```
Router#sh policy-map interface e1/1
 Ethernet1/1  output : mypolicy
  Weighted Fair Queueing
    Class multimedia
      Output Queue: Conversation 264
        Bandwidth 3000 (kbps) Packets Matched 14335 Max Threshold 64
   (packets)
        (discards/tail drops) 3877/0
    Class www
      Output Queue: Conversation 265
        Bandwidth 2250 (kbps) Packets Matched 11151 Max Threshold 64
   (packets)
        (discards/tail drops) 3269/0
```

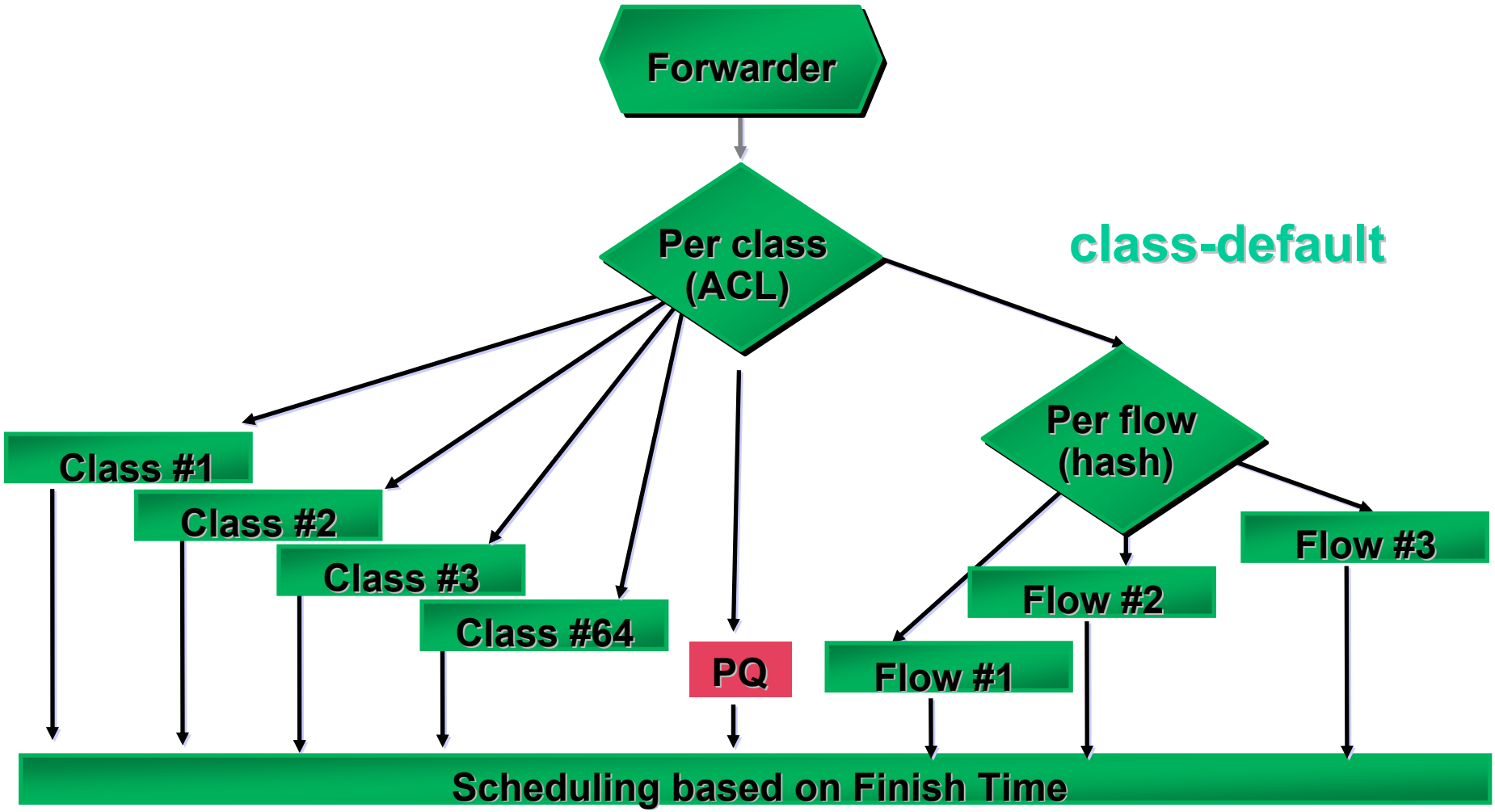
CBWFQ - Example

MSTP

```
Class ftp
    Output Queue: Conversation 266
      Bandwidth 1500 (kbps) Packets Matched
9560 Max Threshold 64 (packets)
      (discards/tail drops) 5051/0
  Class class-default
    Output Queue: Conversation 267
      Bandwidth 750 (kbps) Packets Matched 4462
Max Threshold 64 (packets)
      (discards/tail drops) 1394/0
```

PQ-CBWFQ or Low Latency Queuing (LLQ)

MSTP



PQ-CBWFQ (LLQ)

MSTP

- One Priority Queue PQ
- Multiple Priority Classes
- PQ – min b/w guarantee + rate limiting

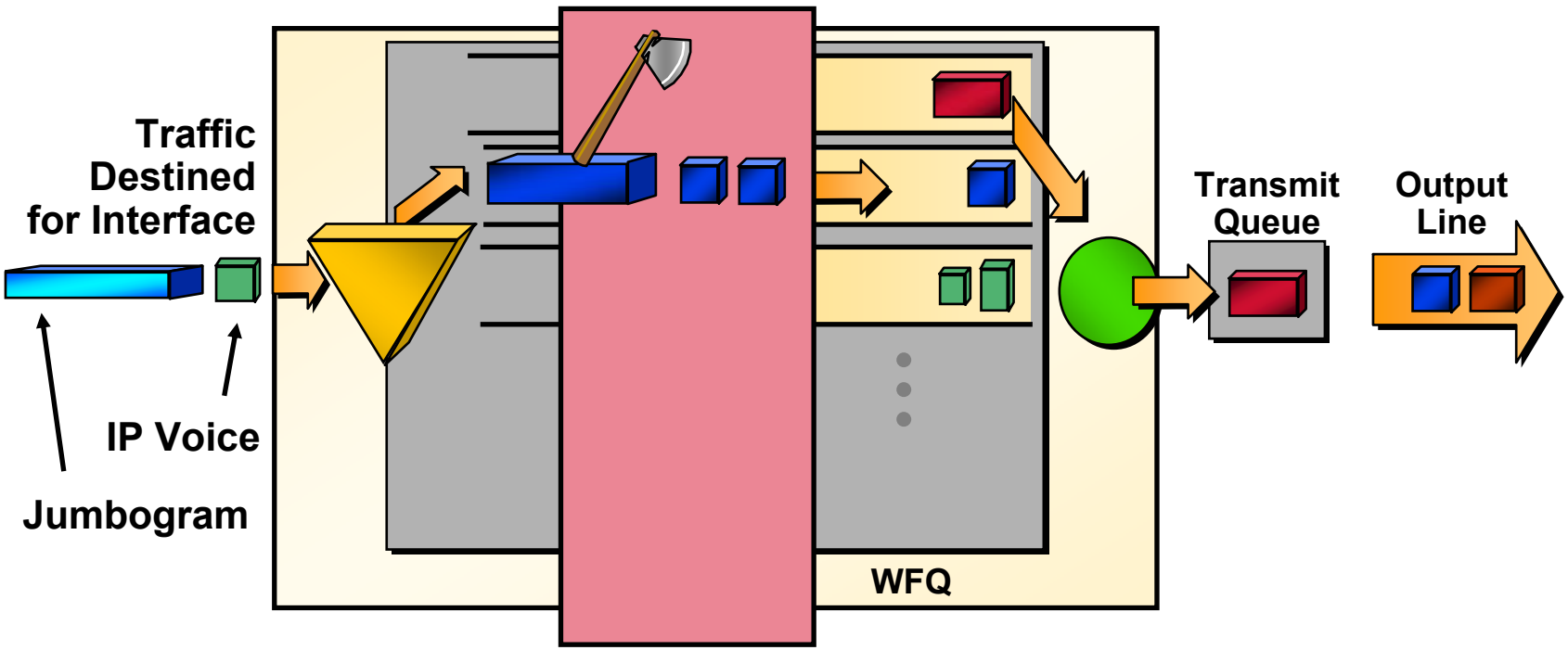
  - In FR case (7200 and below), strict policing irrelevant of congestion.!!

  - All other cases, if no congestion, PQ can use all available b/w. If congestion, rate limited to b/w.

Link Efficiency Mechanisms

Link Fragmentation and Interleaving (LFI)

MSTP



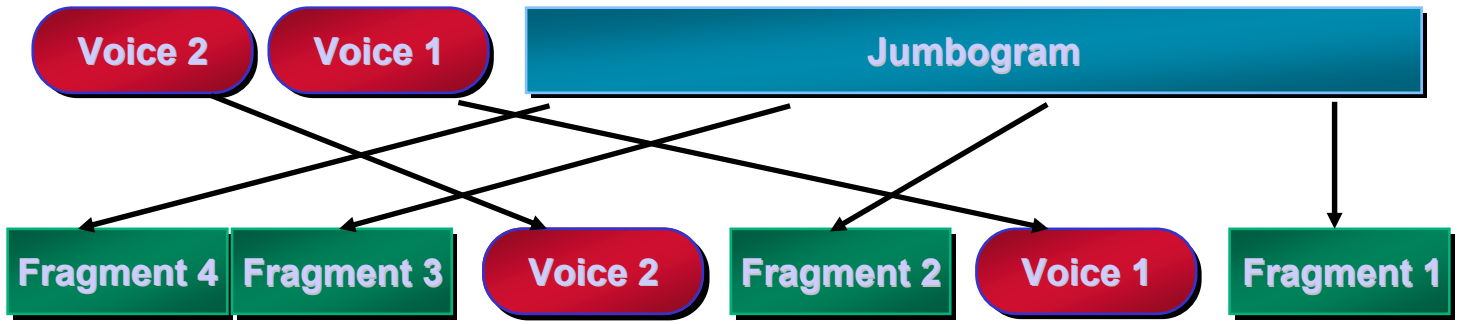
LFI

MSTP

- Fragment Large Size Packets on Slow Links (<768kb/s)
- i.e.1500 Byte takes 215 ms on a 56kbs link
- Optimize voice delay and jitter
- same mechanism for Frame Relay

MultilinkPPP / FRF.11 & .12

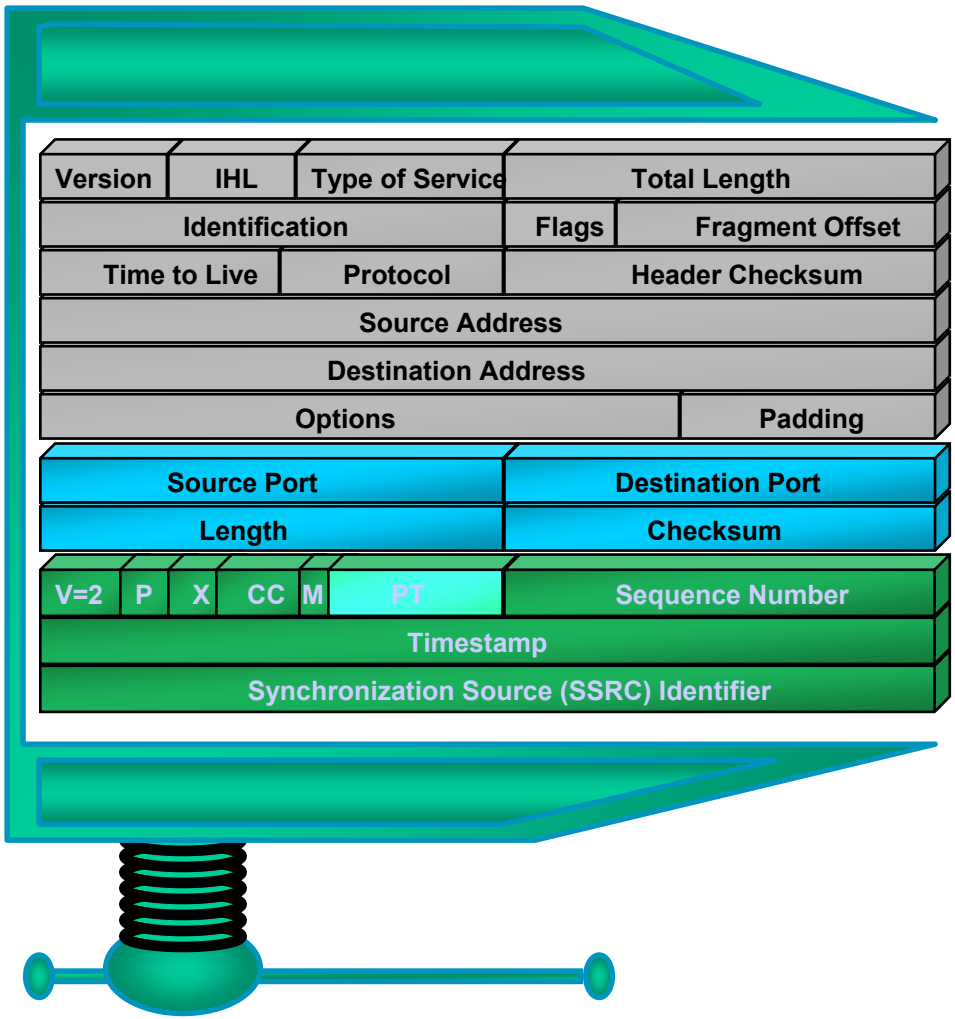
MSTP



- Line overhead
- Segmentation/reassembly overhead

cRTP

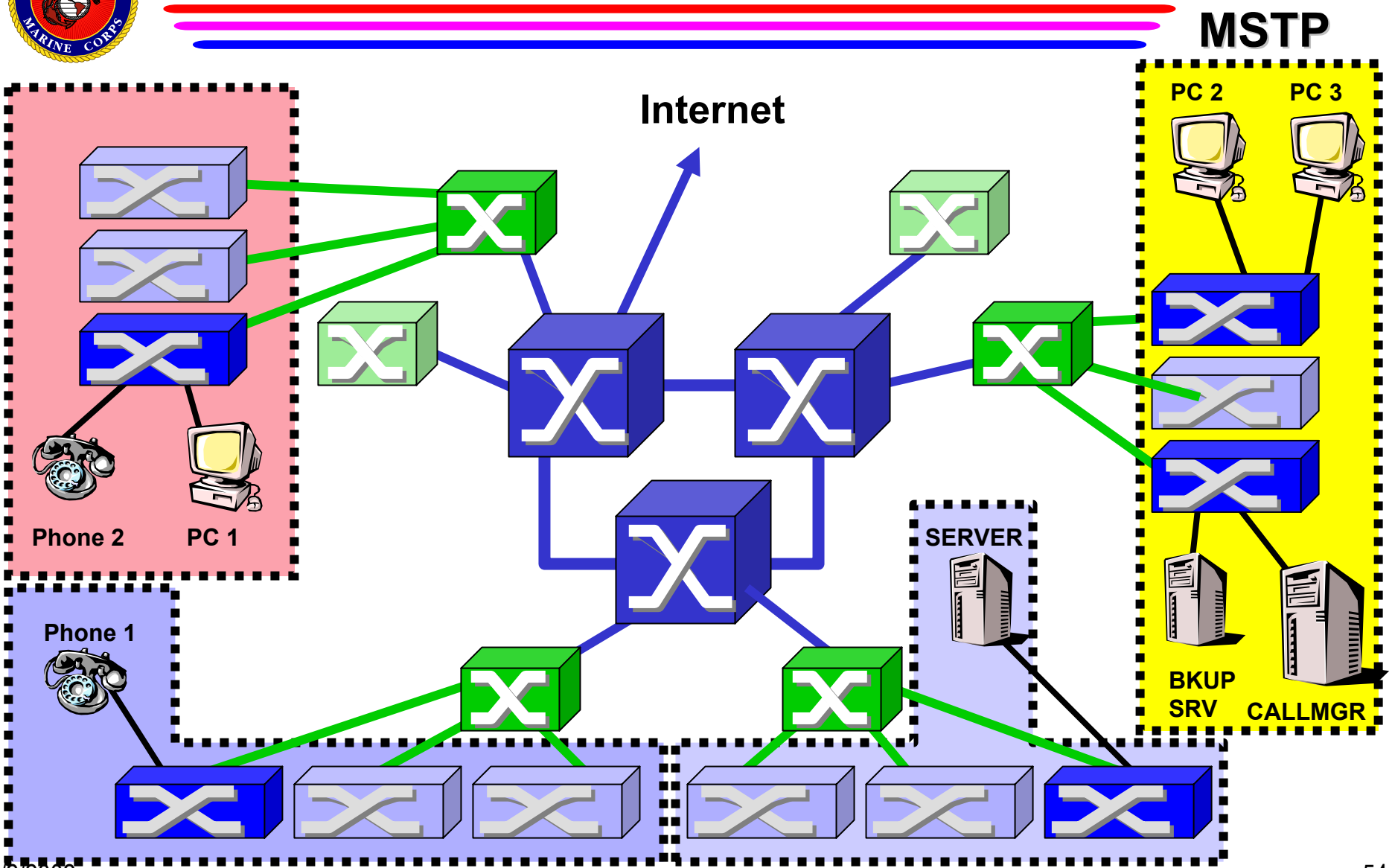
MSTP



- Voice Packet typical payload 20bytes
- Header 40 bytes (20 IP, 8 UDP, 12 RTP)
- CRTP reduces header to 2-4 bytes
- Is Process Switched
- Fast switched in 12.0(7)T
- Fast switched enhancements in 12.1(2)T
- Distributed cRTP in 12.1(5)T

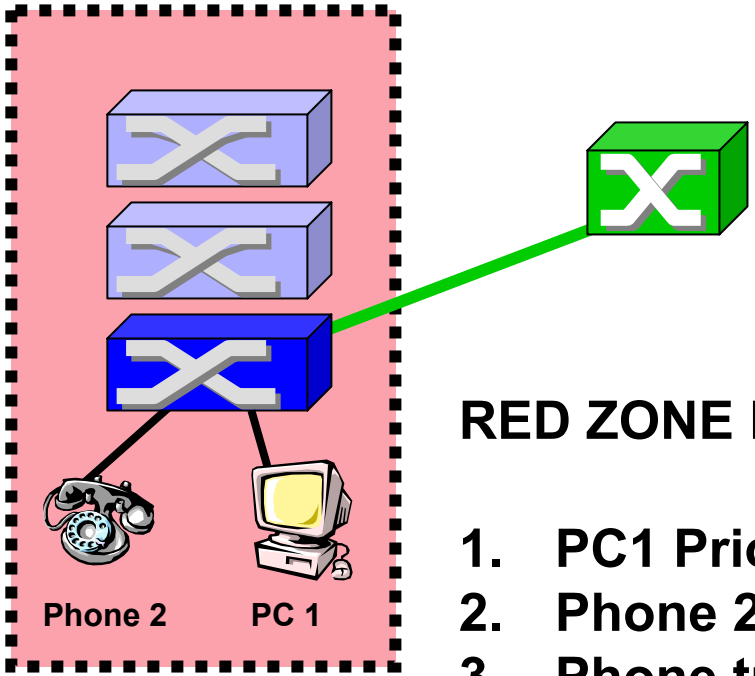
Deployment Example

Deployment Scenario



QoS Requirements

MSTP



RED ZONE Network requirements for QoS as follows

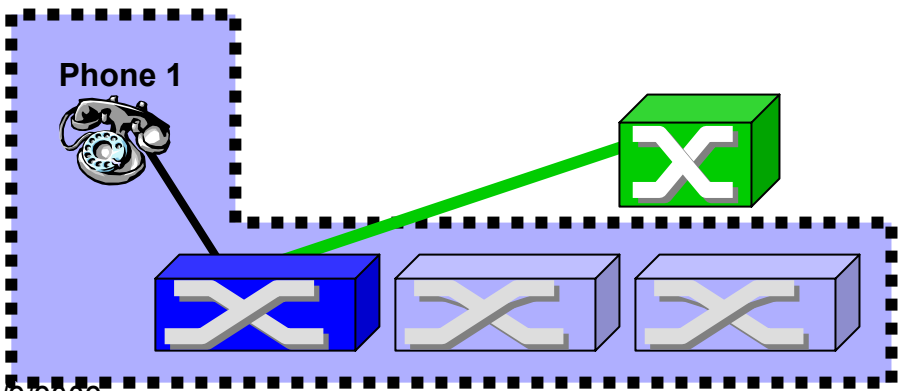
1. **PC1 Priority setting to be reset to ZERO**
2. **Phone 2 Priority to be maintained**
3. **Phone traffic to be sent immediately**
4. **PC1 traffic to be sent only when NO Voice traffic**
5. **Uplink to prioritise voice traffic over data traffic**

QoS Requirement

MSTP

BLUE ZONE Network requirements for QoS as follows

1. **Phone 1 Priority setting to be maintained**
2. **Phone traffic to be sent immediately on Uplink ahead of other traffic**

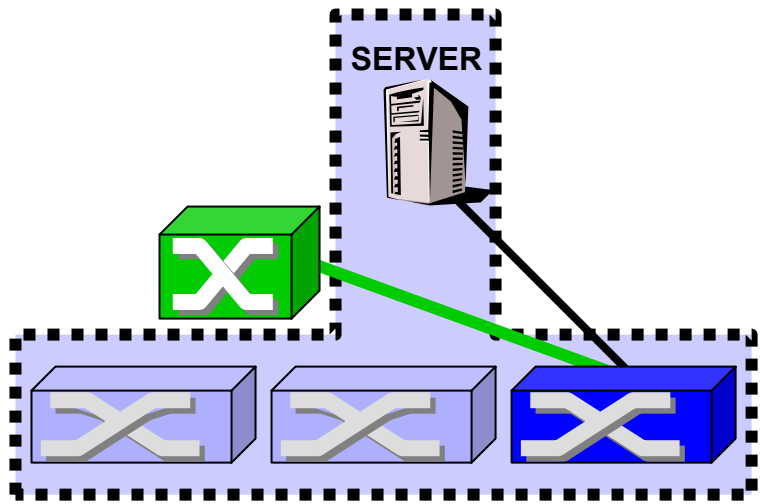


QoS Requirement

MSTP

ORANGE ZONE Network requirements for QoS as follows

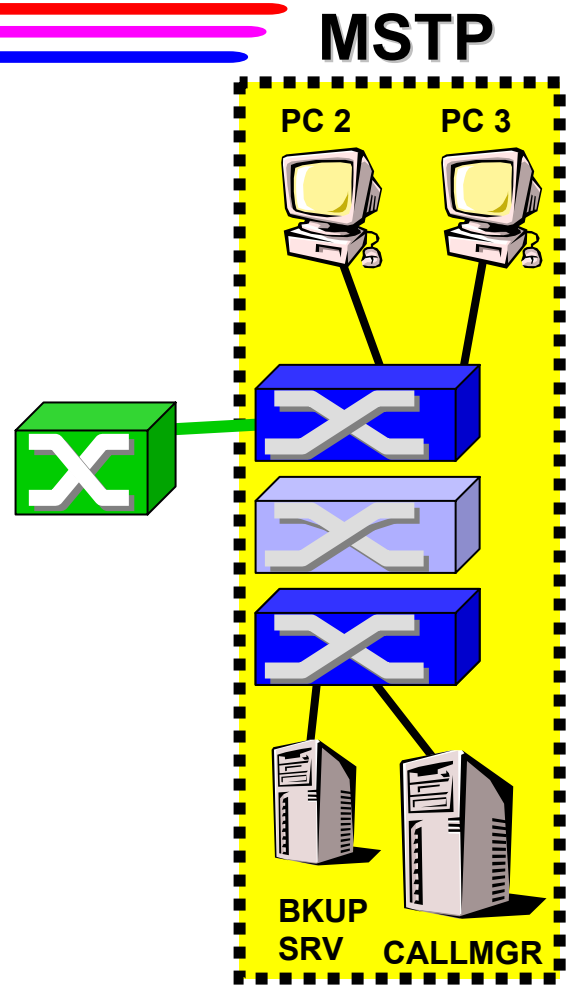
1. **File Server Priority setting to 4**
2. **File Server traffic to have priority over other traffic on uplink**
3. **Uplink port to have WRED enabled**



QoS Requirement

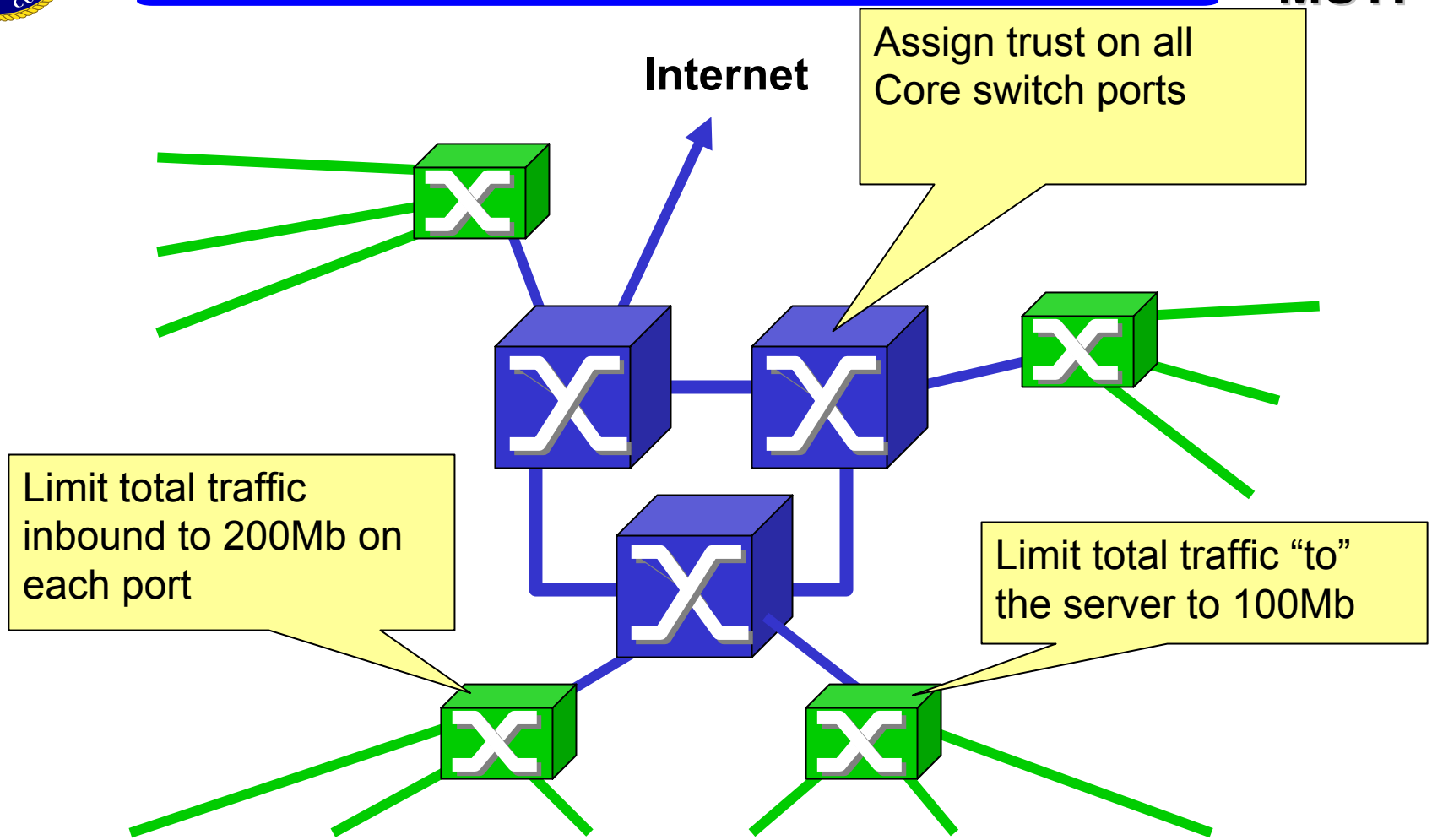
YELLOW ZONE Network requirements for QoS as follows

1. **Callmanager traffic priority setting to be maintained**
2. **PC2 Priority to be set to ZERO**
3. **PC3 Priority to be set to 2**
4. **Uplink to prioritise voice over data traffic**
5. **PC2 traffic to be rate limited to 5Mb**



QoS Requirement

MSTP

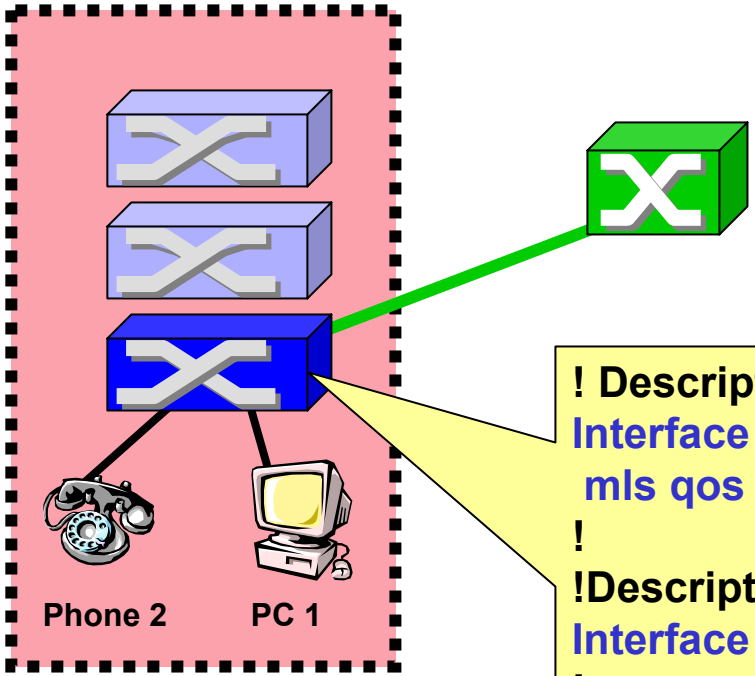


Putting it All Together

QoS Requirements – 2950G

MSTP

1. PC1 Priority setting to be reset to ZERO
2. Phone 2 Priority to be maintained
3. Phone traffic to be sent immediately and PC1 traffic to be sent only when NO Voice traffic
4. Uplink to prioritise voice traffic over data traffic

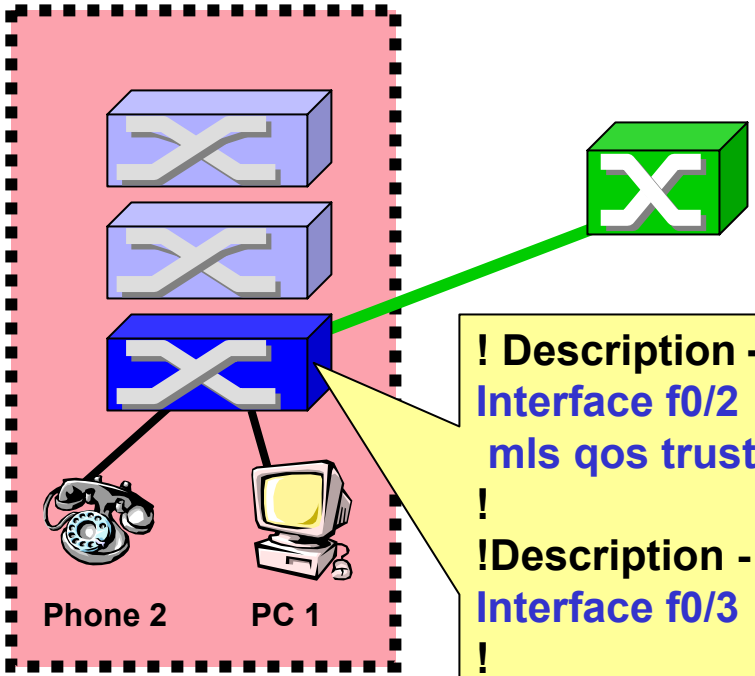



```
! Description – Phone 2 port
Interface f0/2
 mls qos trust cos
!
!Description - PC 1 port – default is untrusted
Interface f0/3
!
!Description – Uplink Port uses strict priority
Interface g0/0
 no wrr-queue bandwidth
```

QoS Requirements – 3550

MSTP

1. PC1 Priority setting to be reset to ZERO
2. Phone 2 Priority to be maintained
3. Phone traffic to be sent immediately and PC1 traffic to be sent only when NO Voice traffic
4. Uplink to prioritise voice traffic over data traffic



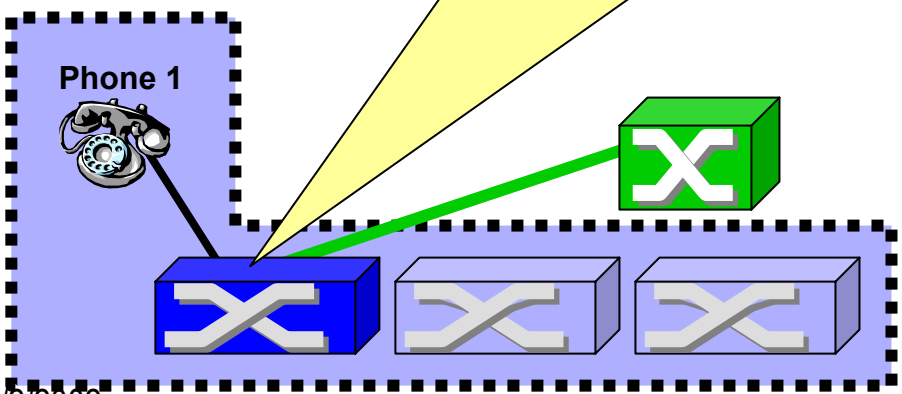

```
! Description – Phone 2 port
Interface f0/2
 mls qos trust cos
!
!Description - PC 1 port – default is untrusted
Interface f0/3
!
!Description – Uplink Port uses strict priority
Interface g0/0
 priority-queue out – enables strict priority
 wrr-queue cos-map 4 5 – maps cos 5 to SP queue (4)
 wrr-queue cos-map 3 6 7 – maps cos 6,7 to queue 3
```

QoS Requirement – 2950G

MSTP

1. Phone 1 Priority setting to be maintained
2. Phone traffic to be sent immediately on Uplink ahead of other traffic

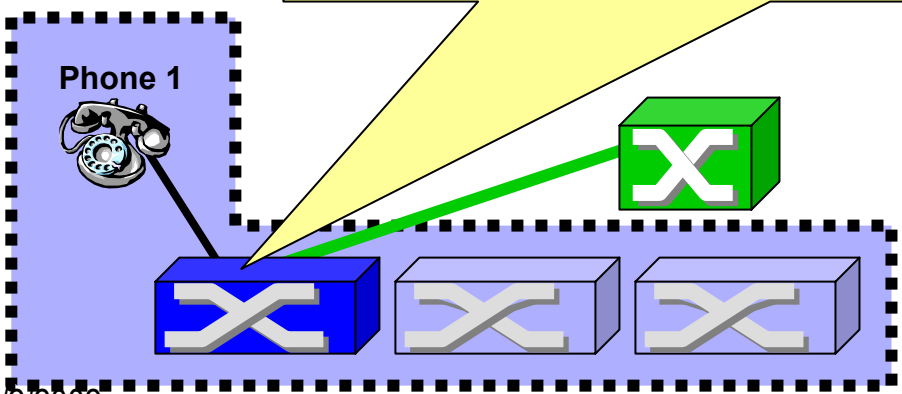
```
! Description – Phone 1 port
Interface f0/2
 mls qos trust cos
!
!Description – Uplink Port uses strict priority
Interface g0/0
 no wrr-queue bandwidth
```



QoS Requirement - 3550

MSTP

```
! Description – Phone 2 port
Interface f0/2
 mls qos trust cos
!Description – Uplink Port uses strict priority
Interface g0/0
 priority-queue out – enables strict priority
 wrr-queue cos-map 4 5 – maps cos 5 to SP queue (4)
 wrr-queue cos-map 3 6 7 – maps cos 6,7 to queue 3
```



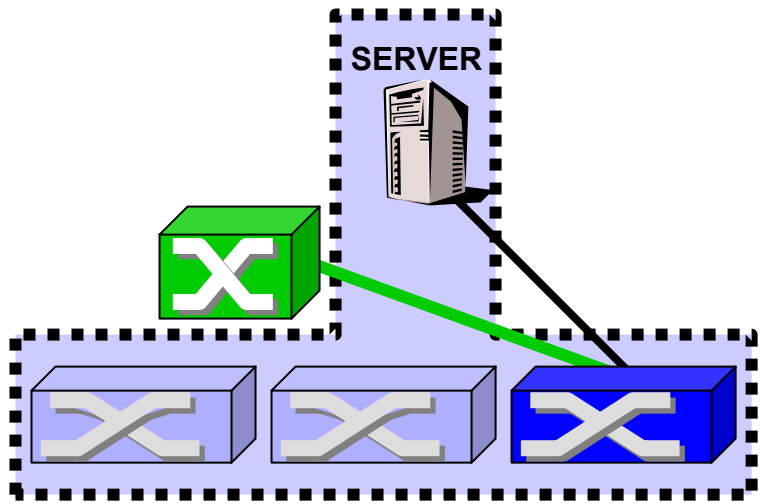
1. Phone 1 Priority setting to be maintained
2. Phone traffic to be sent immediately on Uplink ahead of other traffic

Deployment Scenario – 2950G

MSTP

```
!Description – server port
Interface f0/1
 mls qos cos 4 override
!Description – Uplink Port uses strict priority
Interface g0/0
 no wrr-queue bandwidth – enables strict priority
 wrr-queue cos-map 4 4 – maps cos 4 to highest priority queue
```

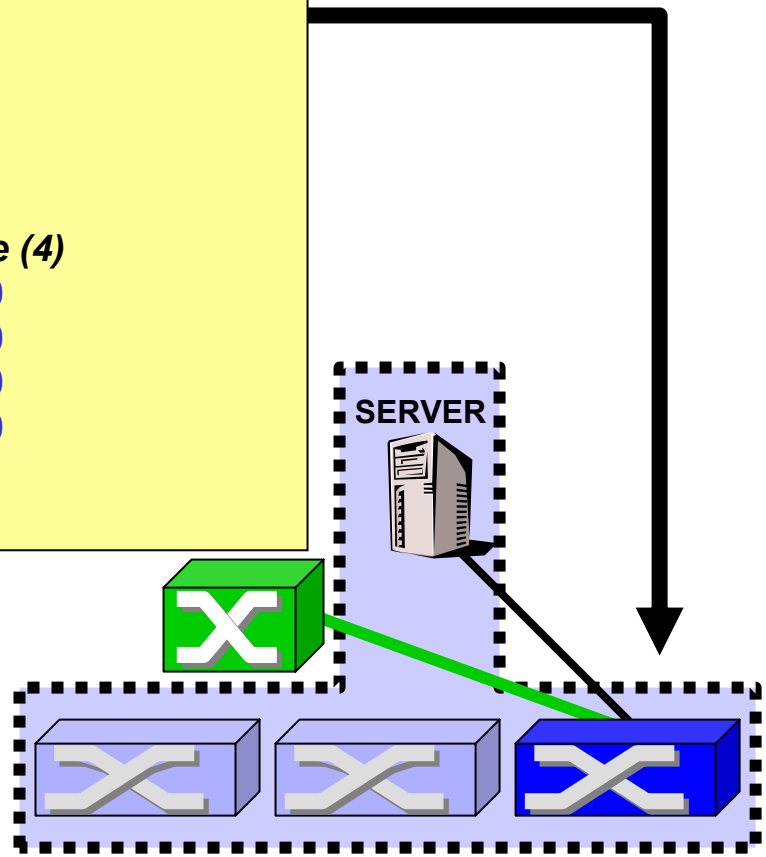
1. File Server Priority setting to 4
2. File Server traffic to have priority over other traffic on uplink
3. Uplink port to have WRED enabled (NOT AVAILABLE ON 2950G)



Deployment Scenario - 3550

MSTP

```
Access-list 101 permit ip host 10.1.1.1 any
Policy-map set-priority
 class access-group 101
  set ip prec 4
!Description – set server port traffic to priority 4
Interface f0/1
 service-policy input set-priority
!Description – Uplink Port uses strict priority
Interface g0/0
 priority-queue out – enables strict priority
 wrr-queue cos-map 4 4 – maps cos 4 to SP queue (4)
 wrr-queue random-detect max-threshold 1 40 100
 wrr-queue random-detect max-threshold 2 60 100
 wrr-queue random-detect max-threshold 3 40 100
 wrr-queue random-detect max-threshold 4 60 100
 wrr-queue dscp-map 1 0 8 16 24 32 40 48 56
 wrr-queue dscp-map 1 2 10 20 31 39 47 52
```

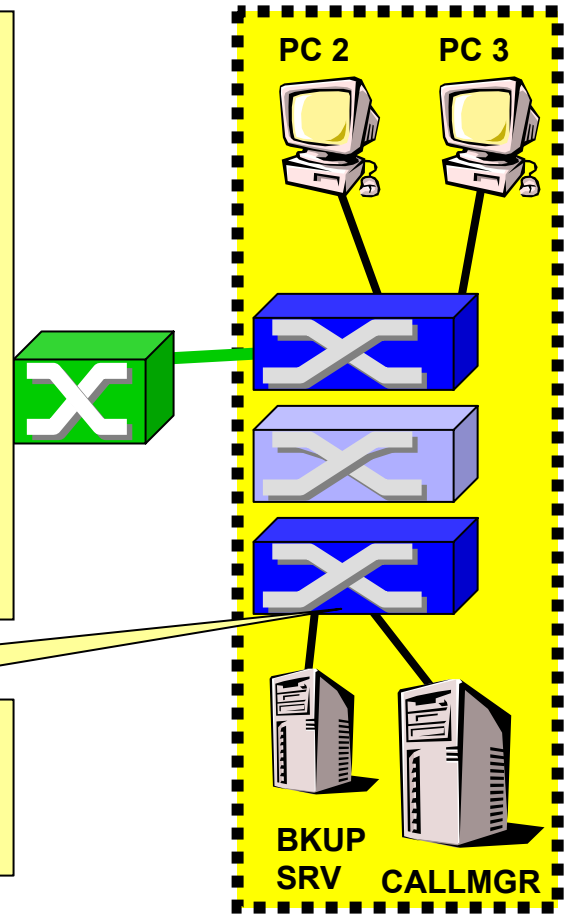


1. File Server Priority setting to 4
2. File Server traffic to have priority over other traffic on uplink
3. Uplink port to have WRED enabled

Deployment Scenario – 2950G

```
!Description – PC2 port
Interface f0/2
 mls qos cos 0 override
!Description – PC3 port
Interface f0/3
 mls qos cos 2 override
!Description – Uplink Port uses strict priority
Interface g0/0
 no wrr-queue bandwidth – enables strict priority
 wrr-queue cos-map 4 5 – maps cos 5 to highest priority queue
[snip…con't on next page]
```

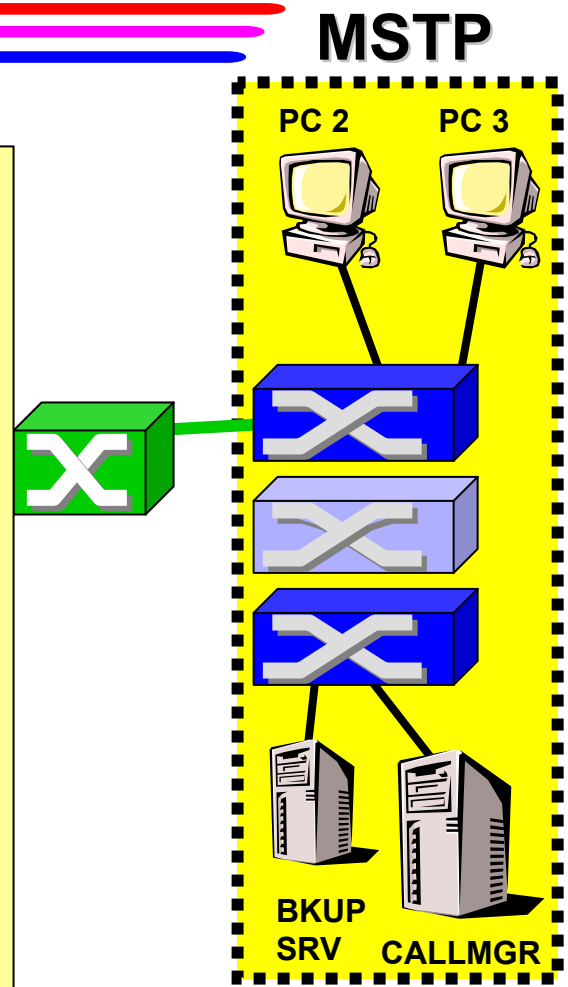
```
!Description – CALLMGR port
Interface f0/1
 mls qos trust cos
```



1. Callmanager traffic priority setting to be maintained
2. PC2 Priority to be set to ZERO
3. PC3 Priority to be set to 2
4. Uplink to prioritise voice over data traffic

Deployment Scenario – 2950G con't

```
!Define ACL and class map to classify traffic
Access-list 101 permit ip any any
!
Class-map rate-limit-to-5Mb
 match access-group 101
!
!Description – Define policy map to set policer – defines rate
!in bps and drops excess traffic
Policy-map limit-traffic
 class rate-limit-to-5Mb
   police 5000000 4096 exceed-action drop
!
!Description
Interface f0/2
 mls qos cos 0 override  << from previous page
 service-policy input limit-traffic  << applies policer to interface
```

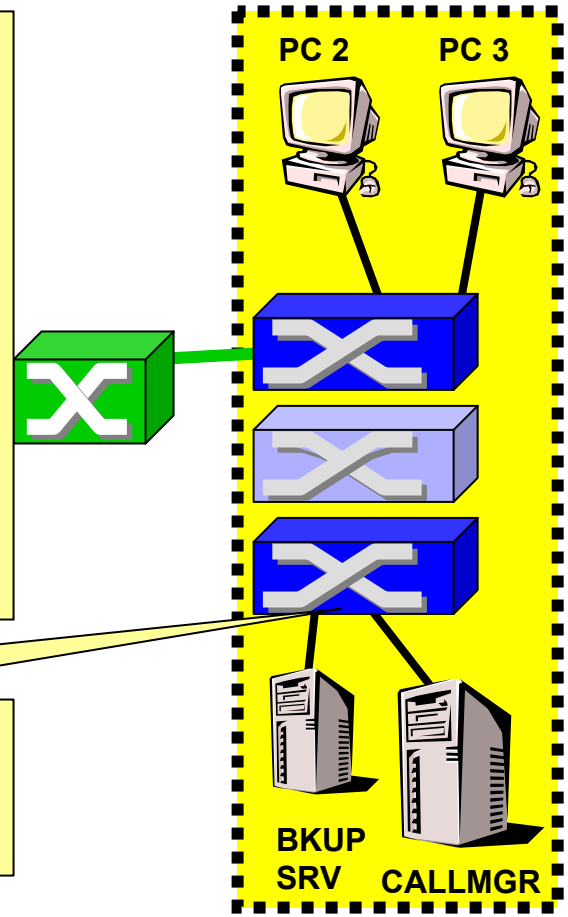


5. PC2 traffic to be rate limited to 5Mb

Deployment Scenario - 3550

!Description – PC2 port
Interface f0/2
 no mls qos trust
!Description – PC3 port
Interface f0/3
 mls qos cos 2 override
!Description – Uplink Port uses strict priority
Interface g0/0
 priority-queue out – *enables strict priority*
 wrr-queue cos-map 4 5 – *maps cos 5 to highest priority queue*
[snip…con't on next page]

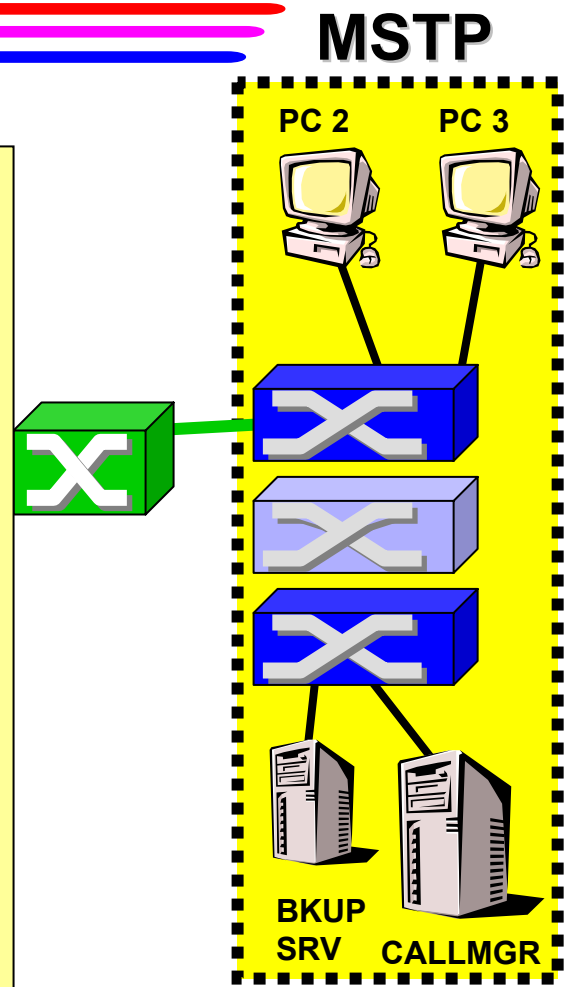
!Description – CALLMGR port
Interface f0/1
 mls qos trust cos



1. Callmanager traffic priority setting to be maintained
2. PC2 Priority to be set to ZERO
3. PC3 Priority to be set to 2
4. Uplink to prioritise voice over data traffic

Deployment Scenario – 3550 con't

```
!Define ACL and class map to classify traffic
Access-list 101 permit ip any any
!
Class-map rate-limit-to-5Mb
 match access-group 101
!
!Description – Define policy map to set policer – defines rate
!in bps and drops excess traffic
Policy-map limit-traffic
 class rate-limit-to-5Mb
   police 5000000 8000 exceed-action drop
!
!Description
Interface f0/2
 mls qos cos 0 override  << from previous page
 service-policy input limit-traffic  << applies policer to interface
```



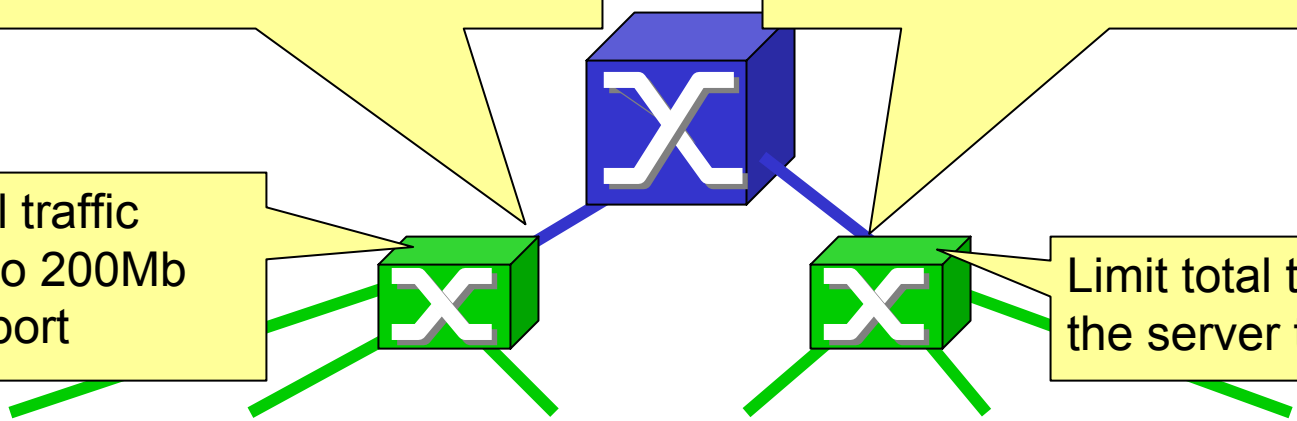
5. PC2 traffic to be rate limited to 5Mb

Deployment Scenario – 4000 (SUPIII)

MSTP

```
Access-list 101 permit ip any 10.1.1.1
!
Class-map rate-limit-to-200Mb
 match access-group 101
!
Policy-map limit-traffic
 class rate-limit-to-200Mb
   police 200000000 8000 exceed-action drop
!
Interface f0/2
service-policy input limit-traffic
```

```
Access-list 102 permit ip any 10.1.1.1
!
Class-map rate-limit-to-100Mb
 match access-group 101
!
Policy-map limit-server-traffic
 class rate-limit-to-100Mb
   police 100000000 8000 exceed-action drop
!Apply to uplink interface to Core
Interface g0/0
service-policy input limit-server-traffic
```



Limit total traffic inbound to 200Mb on each port

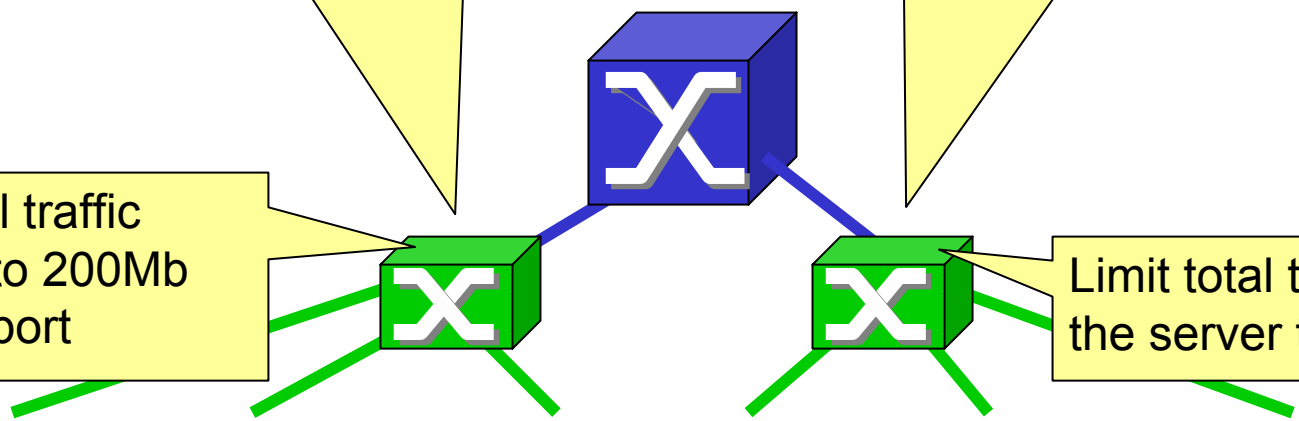
Limit total traffic “to” the server to 100Mb

Deployment Scenario – 6500 (CatOS)

MSTP

```
Console>(enable) set qos policer aggregate
limit-200 rate 200000 burst 13 drop
Console>(enable) set qos acl ip test1 trust-
cos aggregate limit-200 ip any any
Console>(enable)
Console>(enable) commit qos acl all
Console>(enable)
Console>(enable) set qos acl map test1 2/1
```

```
Console>(enable) set qos policer aggregate
limit-100 rate 100000 burst 13 drop
Console>(enable) set qos acl ip test1 trust-
cos aggregate limit-100 ip any 10.1.1.1
Console>(enable)
Console>(enable) commit qos acl all
Console>(enable)
Console>(enable) set qos acl map test1 3/1
```



Limit total traffic inbound to 200Mb on each port

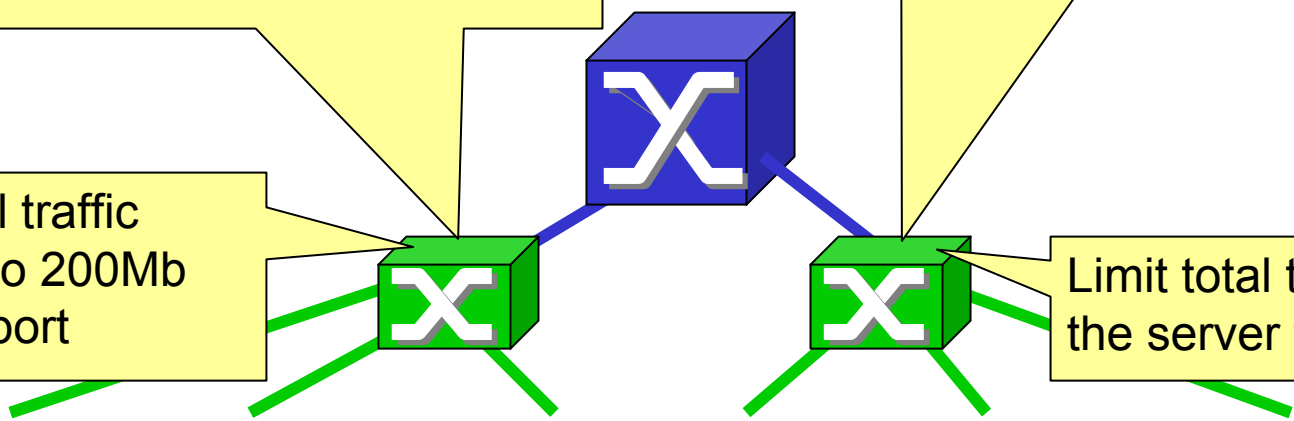
Limit total traffic “to” the server to 100Mb

Deployment Scenario – 6500 (Cisco IOS)

MSTP

```
Access-list 101 permit ip any any
!
Class-map rate-limit-to-200Mb
 match access-group 101
!
Policy-map limit-traffic
 class rate-limit-to-200Mb
   police 200000000 8000 exceed-action drop
!
Interface f2/1
service-policy input limit-traffic
```

```
Access-list 102 permit ip any any
!
Class-map rate-limit-to-100Mb
 match access-group 101
!
Policy-map limit-server-traffic
 class rate-limit-to-100Mb
   police 100000000 8000 exceed-action drop
!Apply to uplink interface to Core
Interface g3/1
service-policy input limit-server-traffic
```



Limit total traffic inbound to 200Mb on each port

Limit total traffic “to” the server to 100Mb

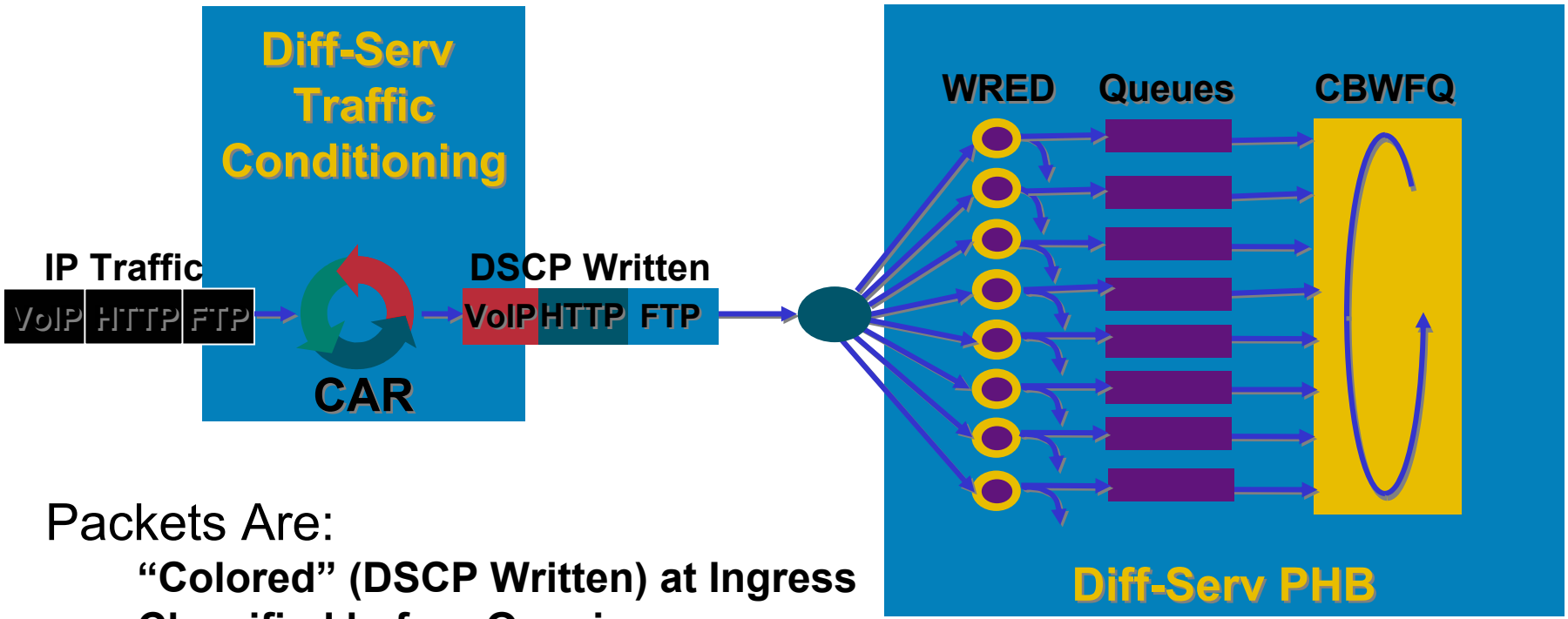
Diffserv Building Blocks

MSTP

- Classifiers:
  - –Sort packets by anything in the headers – addresses, ports, DSCPs, application data (NBAR)
- Policers:
  - –Take action (drop, remark) based on conformance to token bucket (rate, burst) – downstream of “trust boundary”
- Shapers:
  - –Delay packets to ensure conformance to a token bucket – upstream of trust boundary
- Schedulers:
  - –WFQ, WRR, CBWFQ, priority (LLQ), hierarchical
- Droppers:
  - –WRED, Tail-drop

Putting It All Together

MSTP



Packets Are:

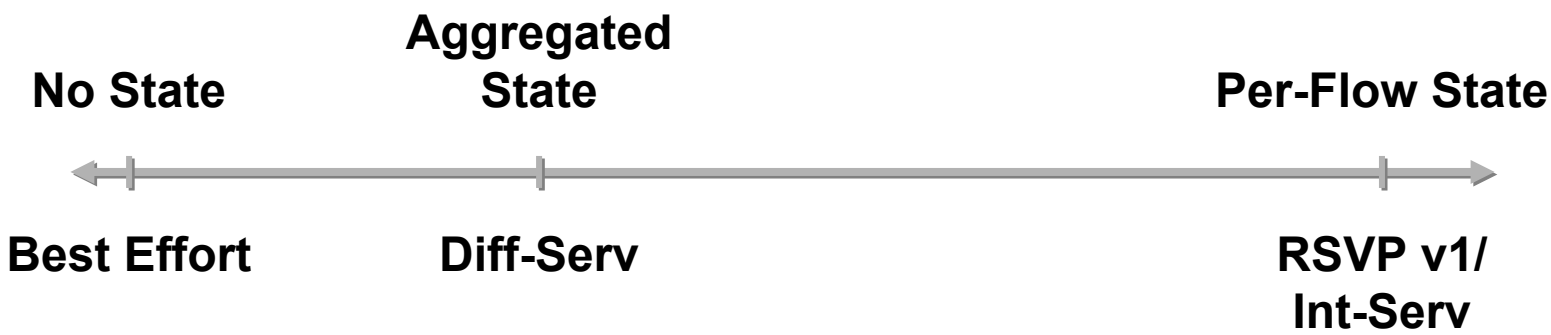
- **"Colored" (DSCP Written) at Ingress**
- **Classified before Queuing**
- **Potentially Discarded by WRED**
- **Placed in Queues Based on DSCP**
- **Scheduled by CBWFQ (and/or LLQ)**

What Is RSVP Good For?

- Making firm-hard reservations for individual application flows
  - –Topology-aware admission control is ideal for voice
- Main drawback: per flow state in routers
  - –Scaling properties not attractive to ISPs
- Valuable today in enterprise nets
  - –E.g. Admission control on a WAN link

QoS Spectrum

- Diffserv created largely in response to scaling concerns about RSVP



The Trouble with Diff-Serv

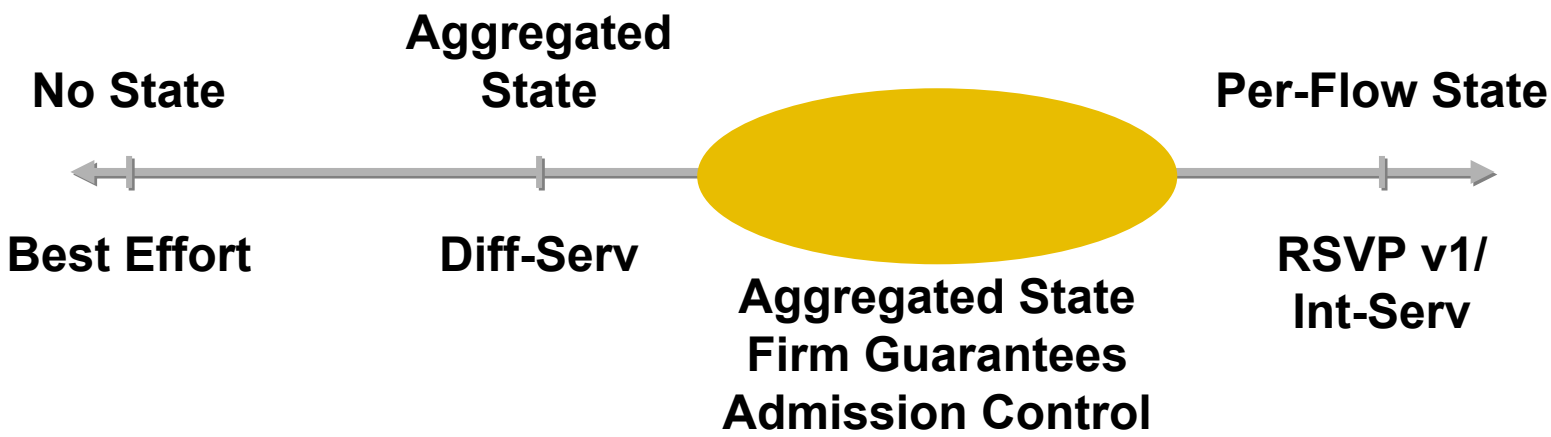
MSTP

- As currently formulated, Diff-Serv is strong on simplicity and weak on guarantees
- Virtual wire using EF is quite firm, but how much can be deployed?
  - –No topology-aware admission control mechanism
- Example: How do I reject the “last straw” VOIP call that will degrade service of calls in progress?

RSVP/Diff-Serv Integration

MSTP

- The best of both worlds...



MPLS and IP QoS

- First order of business for MPLS:
  Support the complete IP QoS model
  - –Diff-Serv—draft-ietf-mpls-diff-ext-09.txt
  - –Int-Serv—RSVP extensions allow labels to be bound to reservations
  - –Initial goal: Neither more nor less than IP QoS

Constraint-Based Routing

- IP QoS has typically assumed complete separation of routing and QoS
  - –Routing determines the path, QoS determines resource allocation on the path
- What about picking a path with appropriate resources?
  - –Constraint-based routing: Picking a path that meets certain constraints (e.g. sufficient BW, low delay)

Is Current IP Routing Sufficient?

- Conventional IP routing distributes consistent view of network to all nodes in an area
- In constraint-based routing, packets from different sources may need to be forwarded according to different constraints

Is Current IP Routing Sufficient? (Cont.)

- Conventional IP routing uses pure destination-based forwarding
- In constraint-based routing, packets from different sources may need to be forwarded according to different constraints
  - –Need some “source routing” capability
  - –IP source route option has limitations

Role of MPLS

- An MPLS LSP can be explicitly routed along a path that meets the constraints
  - –Using explicit route object + label object in RSVP
- Resources may be allocated at time of LSP establishment

Conclusions

- Three main elements to Cisco's QoS Architecture:
  - –Diffserv: scalable, simple, should be on all platforms
  - –RSVP: the admission control solution
  - –MPLS: Constraint-based routing in large backbones
- Consistency of features and configuration is critical to success